Electronic Services - Los Angeles
M10342X

Ballantine

1040 SERIES

MP MASTER
MA31962

INSTRUCTION MANUAL

1040A DUAL-TRACE DELAYED TIMEBASE OSCILLOSCOPE

1040A-MOD 49 SERIES
VHF & GENERAL PURPOSE OSCILLOSCOPE

1046A DUAL-TRACE OSCILLOSCOPE

1040 SERIES

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FEBRUARY 1977

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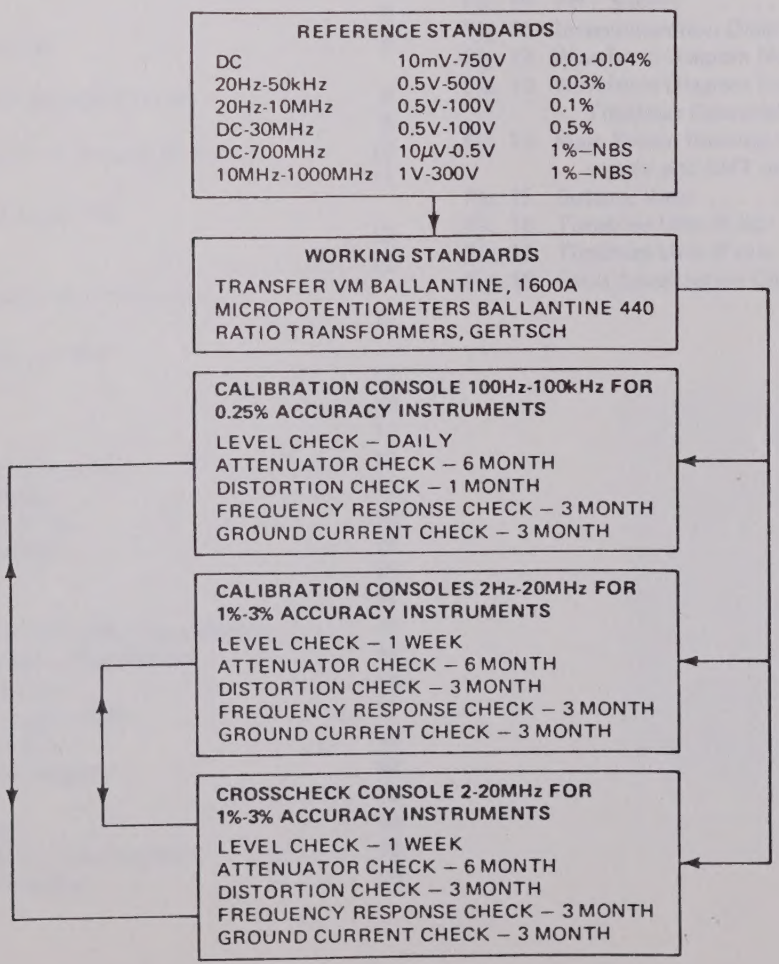
REFERENCE STANDARDS
DC 10mV-750V 0.01-0.04%
20Hz-50kHz 0.5V-500V 0.03%
20Hz-10MHz 0.5V-100V 0.1%
DC-30MHz 0.5V-100V 0.5%
DC-700MHz 10μV-0.5V 1%—NBS
10MHz-1000MHz 1V-300V 1%—NBS
WORKING STANDARDS
TRANSFER VM BALLANTINE, 1600A
MICROPOTENTIOMETERS BALLANTINE 440
RATIO TRANSFORMERS, GERTSCH
CALIBRATION CONSOLE 100Hz-100kHz FOR 0.25% ACCURACY INSTRUMENTS
LEVEL CHECK – DAILY
ATTENUATOR CHECK – 6 MONTH
DISTORTION CHECK – 1 MONTH
FREQUENCY RESPONSE CHECK – 3 MONTH
GROUND CURRENT CHECK – 3 MONTH
CALIBRATION CONSOLES 2Hz-20MHz FOR 1%-3% ACCURACY INSTRUMENTS
LEVEL CHECK – 1 WEEK
ATTENUATOR CHECK – 6 MONTH
DISTORTION CHECK – 3 MONTH
FREQUENCY RESPONSE CHECK – 3 MONTH
GROUND CURRENT CHECK – 3 MONTH
CROSSCHECK CONSOLE 2-20MHz FOR 1%-3% ACCURACY INSTRUMENTS
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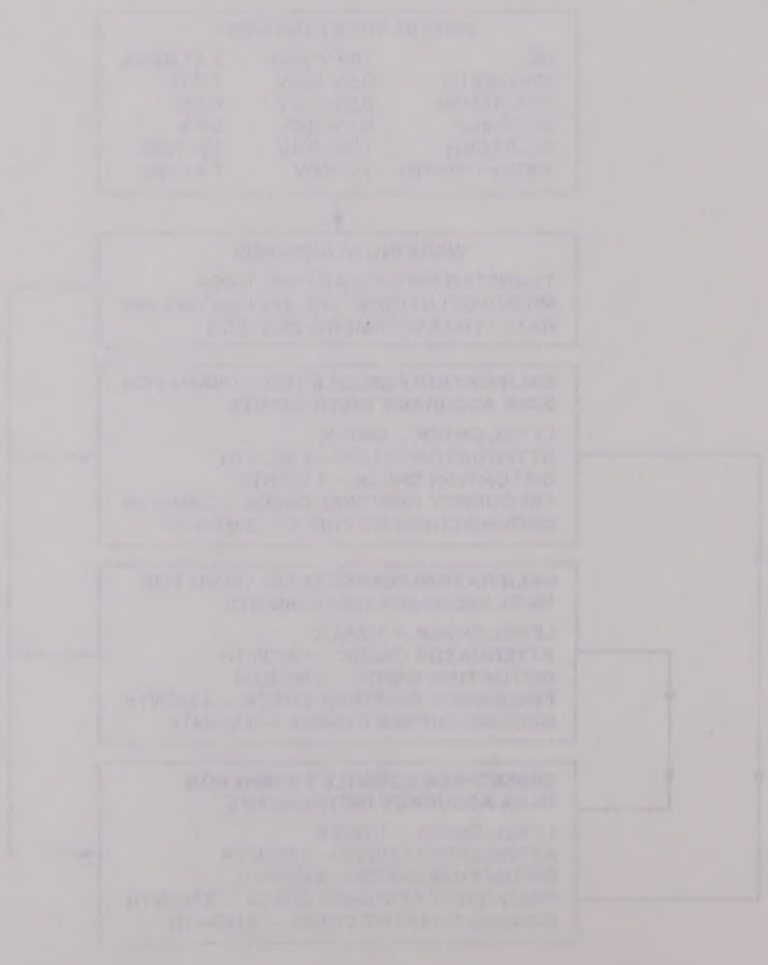
FREQUENCY RESPONSE CHECK – 3 MONTH
GROUND CURRENT CHECK – 3 MONTH

Ballantine's Quality Assurance program satisfied the requirements of MIL-I-45208



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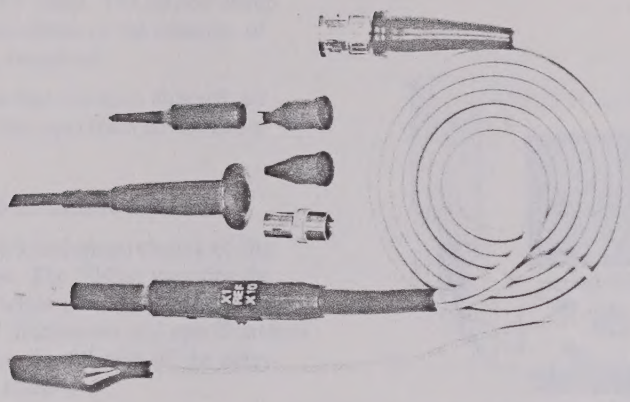
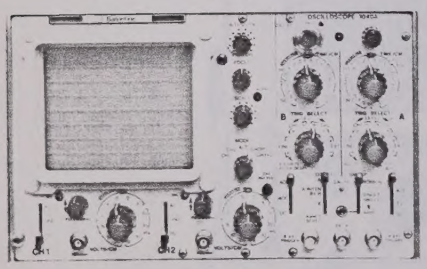
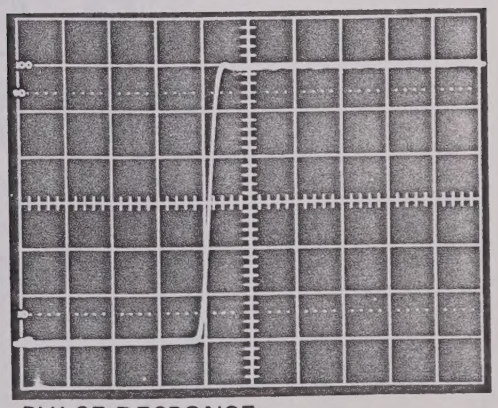


10601C PROBE & ACCESSORIES

RACK MOUNT ASSEMBLY



Refer to Page 3 for a listing of the optional accessories available for use with the 1040 Series Oscilloscopes.



PULSE RESPONSE
Input $T_R \approx 750$ ps/50 Ω
Scope Rise Time ≈ 9 ns

Introduction

Section 1

1040 SERIES DUAL TRACE OSCILLOSCOPES

The Ballantine 1040A is a lightweight dual-trace oscilloscope. Its facilities make it particularly suitable for General Purpose and High Quality laboratory work, and its size and light weight suit it for portable servicing applications of an exacting nature such as computers and data processors.

The high sensitivity and fast timebase speeds make the instrument ideal for the display of fast transients, and the comprehensive dual timebases allow detailed examination of complex waveforms and pulse trains. The mixed sweep facility gives continuous identification of the location of the section of waveform being examined.

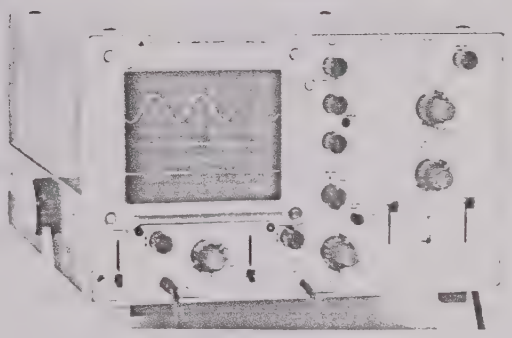
Triggering facilities are independent for each channel, an essential feature for TV and pulse operation to eliminate waveform jitter.

1046A SINGLE TIME BASE OSCILLOSCOPE

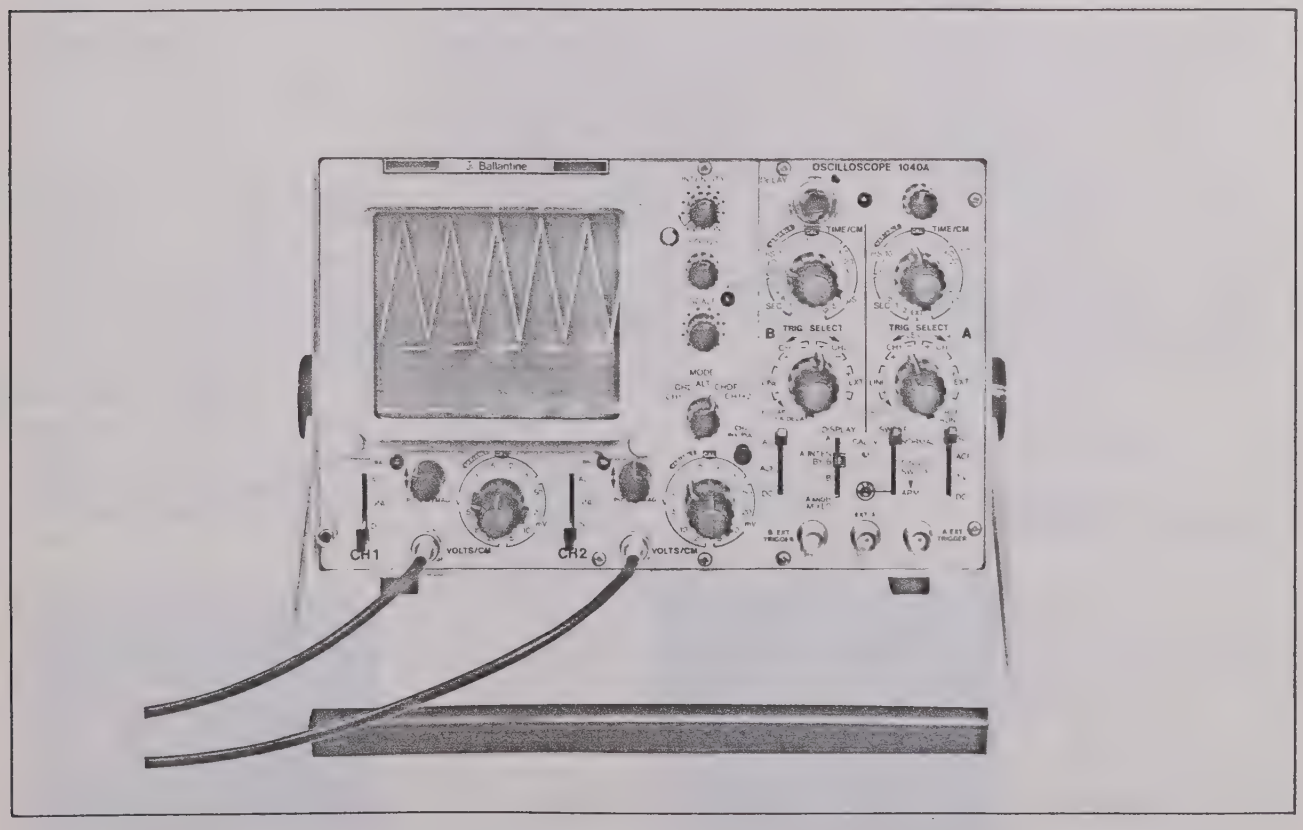
This manual covers the operation and maintenance of the 1040A and 1046A oscilloscopes. The 1040A includes the dual time base delaying sweep while the 1046A includes only a single (A) time base. All discussions and specifications apply to both oscilloscopes with the deletion of the delaying sweep (B time base) in the 1046A.

NOTE

The terms Y1 and CH1 and Y2 and CH2 are used interchangeably thruout this manual to simplify understanding when referring to the vertical amplifier system. The panel of the oscilloscope is marked CH1 and CH2. "A" time base is the main time base and is the delaying time base. It applies to both the 1040A and the 1046A. "B" time base is the delayed time base and is found only in the dual time base 1040A oscilloscope.



1046A Dual Trace Oscilloscope



1040A Dual Trace Delayed Timebase Oscilloscope

CATHODE RAY TUBE

8 x 10 cm rectangular CRT; 10 KV acceleration; illuminated graticule; P31 phosphor standard. P7 and P11 optional.

VERTICAL DEFLECTION (2 Identical Channels)

Deflection Factor: 5mV/cm to 20V/cm in 12 calibrated steps, 1-2-5 sequence, accurate within 3%. Uncalibrated vernier continuously variable between steps with 2.5:1 range extends maximum range to 50 V/cm. X5 mode gives 1 mV/cm, accuracy within 5%; cascaded mode 50 μV/cm.

Bandwidth and Risetime: DC to at least 40MHz at 3dB down, from 50 Ω source. Risetime 9 ns. DC to 10MHz in x 5 mode. Low frequency 3dB down point 5Hz on AC coupling.

Display Modes: Channel 1 only, Channel 2 only (normal or inverted); Channel 1 and 2 alternate; Channel 1 and 2 chopped (500 kHz approximately); Channel 1 and 2 algebraic addition (Channel 2 normal or inverted).

Input R and C: 1 megohm ±2% paralleled by approximately 28 pF.

Maximum Input Voltage: DC coupled ±400 V dc plus peak ac. AC coupled not to exceed ±500 V dc plus peak ac. Maximum ac input is 500 V P-P at 1 kHz or less

Delay Line: Permits viewing leading edge of triggering waveform. At least 5 mm visible delay on fastest sweep.

Internal Trigger Source: Channel 1 only or Channel 2 only; positive or negative polarity.

MAIN TIME BASE (A)

SWEEP

Ranges: 200 ns/cm to 2 s/cm in 22 calibrated steps, 1-2-5 sequence. Accurate within 3%.

Vernier: Continuously variable between steps, extending slowest sweep to approximately 5 s/cm and 50 sec full scale.

Magnifier: Expands all sweeps X10. Makes fastest sweep 20 ns/cm. Accuracy within 5%.

SWEEP TRIGGER MODE

Normal: triggered by internal or external signal.

Single Sweep: Armed manually and then triggers single sweep of time base in normal manner. Light indicates when sweep is armed.

TRIGGERING

Selection:
Internal; Channel 1 or Channel 2, positive or negative
External; positive or negative
Line; positive or negative
Free Run

Level Control:
Manual: Control range 8 cm internal and 20 volts external
Auto: bright line display in absence of signal. Operates from 40Hz to 5MHz; usable beyond 20MHz.

Sensitivity:
Internal: Manual – minimum display height of 2 mm to 5 MHz increasing to 1 cm at 40 MHz.
Auto – min. of 3mm display height
External: Manual – minimum of 300 mV to 5MHz increasing to 1.5V at 40MHz
Auto – min. of 500 mV

Input Coupling: DC, AC, ACF (low frequency reject), TV (triggering through active sync stripper circuit).

DELAYED TIME BASE (B)*

SWEEP

Ranges: Same as A except 21 ranges to 1 s/cm

Vernier: Same as A except slowest sweep approximately 2.5 s/cm

Magnifier: Same as A.

TRIGGERING

Selection: Same as A except no free run.

Level Control: Manual – gated after delay Direct – sweep after delay

Sensitivity: Internal and External – same as A, except Auto not applicable

Input Coupling: DC, AC, ACF

Calibrated Sweep Delay: 10-turn control provides selection of B timebase starting position. Range is 0.2 to 10 x A time/cm setting of 200 ns to 2 seconds (minimum delay time is 200 ns). Accuracy of ±1% of full scale ±3% of reading; linearity ±1.5%; Delay Jitter less than 1 part in 10,000 of scale.

OTHER CHARACTERISTICS

DISPLAY MODES:
A only
A intensified by B*
B only (starts after delay, or triggerable after delay by A)*
A and B mixed*

Horizontal Amplifier: Sensitivity of 1 V/cm; 0.1 V/cm with X10 magnifier; bandwidth DC to 5MHz; input impedance 100 K Ω. Phase shift less than 3° to 500 kHz.

XY Operation: Channel 2 output on rear panel is coupled to Ext. X input with X10 magnified X display. Bandwidth DC to 1MHz at all settings of Channel 2 input attenuator from 5mV/cm to 20V/cm. Phase shift less than 3° at 500 kHz.

External Z Modulation: sensitivity 1 V for visible modulation at low intensity settings to 20 Volts for high trace intensity; frequency response DC to 40MHz; input impedance 47 K Ω.

Outputs:
Amplitude Calibrator: square wave 1 kHz with less than 30 μsec Risetime; 1 V p-p; ±2%; approximately 1 kHz
A Ramp: 0 to +10 V; less than 10 k Ω source impedance
A Gate: 0 to +10 V; less than 10 k Ω source impedance
B Gate: 0 to +10 V; less than 10 k Ω source impedance
Channel 2 Output: 100 mV/cm deflection. BNC connector

GENERAL

Power: Selectable on rear panel switch for 95-111/103-121/111-130/190-222/206-242/222-260 Volts; Approximately 70 VA (60 Watts); 45 to 440Hz

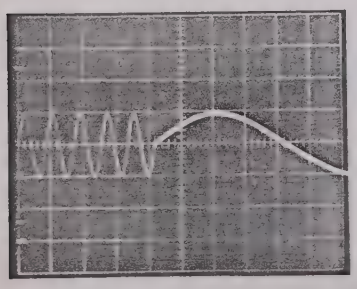
Temperature Range: Non-Operating (storage): –40°C to +75°C
Operating: 0 to 50°C
All stated accuracies apply from 15°C to 30°C. From 0°C to 15°C and from 30°C to 50°C accuracy tolerances widen by 2%.

Dimensions: 178 mm (7 in.) H x 289 mm (11 3/8 in.) W x 422 mm (16 5/8 in.) D.

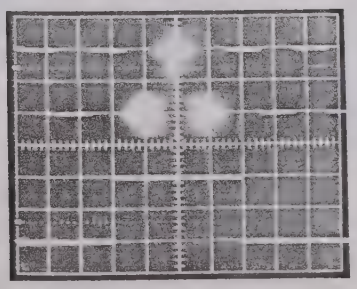
Rack Mount: 178 mm (7 in.) H x 483 mm (19 in.) W x 409 mm (16 1/8 in.) D behind panel.

Weight:
1040A – 12 kg (26 lbs)
1046A – 11 kg (24 lbs)

*** Not applicable to 1046A Dual Trace Oscilloscope**



MIXED SWEEP



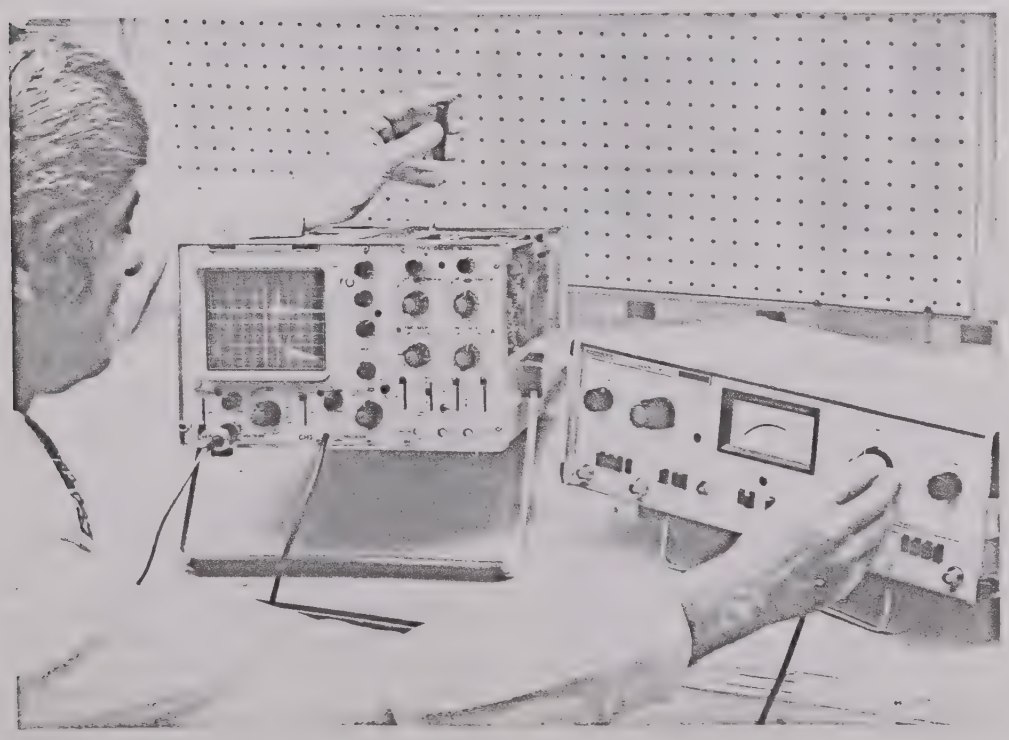
– A Intensified by B

– B Sweep

DELAYED SWEEP

AVAILABLE ACCESSORIES

10601C	Probe Kit, X10, X1 Attenuation and GND. REF., 120 cm (48″), 10MΩ‖11 pF
10702A	Viewing Hood, 8 x 10 cm
10725A	Carrying Case, padded vinyl, luggage type
10750A	Front Panel Protective Cover
800-02	Rack Mount Kit, with 4 feed thru BNC connectors
800-03	Rack Mount Kit (no connectors)
12249A	Cable, BNC-BNC, 20 cm (8″)
12249D	Cable, BNC-BNC, 120 cm (48″)
12250D	Cable, BNC to alligator clips, 120 cm (48″)
12251D	Cable, BNC to double banana plug, 120 cm (48″)
12630A	Termination, Feed-thru, BNC-BNC, 50Ω
6125B	Oscilloscope Calibrator: checks amplitude and sweep accuracies with direct display of percent error, checks rise time.
6130A	Time-mark Generator
7050A	Electronic Signal Recorder: continuous recording magnetic tape loop captures up to 20 msec of signal for instant repetitive replay
10650A	Capacitance Standardizer
10900A	Oscilloscope Cart, adjustable
12631A	Filter, low pass (1 kHz) use with 50μ volt operation to reduce electrical noise.
12619A	Adapter, BNC male to single binding post
12622A	Adapter, BNC male to double banana
88100040A	Timebase extender cable



1040A Adjustment Using Ballantine 6125 Series Oscilloscope Calibrator

3.1. SWITCHING ON

CAUTION The 1040A is convection cooled and must always be operated in a position such that air circulation through the bottom and side vents is not restricted.

1. Set the support/carrying handle to the required operating position. The handle is released by pulling outward both fixing bushes when it can then be turned to lock in any one of 5 positions.
2. ENSURE THAT THE SUPPLY VOLTAGE SELECTOR ON THE REAR PANEL IS SET TO SUIT THE VOLTAGE OF THE SUPPLY TO BE USED. The selector must not be operated while the instrument is switched on. Connect the supply.
3. Turn the INTENSITY control clockwise beyond the POWER OFF setting and ensure that the lamp lights.

3.2 OBTAINING A TRACE

1. To obtain a trace
   (a) Set the Y1 position control to approximately mid setting.
   (b) Set MODE switch to Y1.
   (c) Set the X position control to approximately mid setting.
   (d) Set the A TRIG SELECT switch to FREE RUN.
   (e) Set the A TIME/CM switch to 5μs.
   (f) Set the timebase SWEEP switch to Normal.
   (g) Set the DISPLAY switch to A.
   (h) Adjust the INTENSITY control to obtain a display of the required brightness.
   (i) Center the display by adjusting the Y1 and X position controls.
   (j) Adjust the FOCUS control and ASTIG preset control to obtain a sharply defined trace.

3.3 SETTING UP Y CHANNELS

1. Using one of the coaxial input signal leads (PL43 or PL44), connect a signal to the Y1 or Y2 input socket.
2. For
   (a) Direct connection of the input signal, set the associated AC, GND, DC input lever switch to DC.
   (b) Capacitive coupling of the input signal through an internal 0.1μF 400V capacitor, set the lever switch to AC.

NOTE When examining low amplitude ac signals superimposed on a high dc level, the lever switch should be set to AC and the sensitivity of the Y amplifier increased as in 4.

3. To locate the baseline, set the lever switch to the GND setting. At this setting, the input signal is open circuit and the input of the amplifier is switched to ground.
4. To adjust the sensitivity
   (a) Set the VOLTS/CM switch to a suitable setting. To minimise pick up at sensitive settings, it is essential to ensure that the ground lead connection is near to the signal point.
   (b) If necessary, adjust the concentric VARIABLE control.

NOTE The range of the VARIABLE control is approximately 3:1 so that its full adjustment overlaps the adjacent lower sensitivity range. Except at the CAL setting, the VARIABLE control is uncalibrated. At the CAL setting, the calibration corresponds to the setting of the VOLTS/CM switch.

5. For vertical movement of the trace, adjust the Y shift controls (identified with vertical arrows).
6. If, under no signal conditions, trace movement is detected when the VARIABLE is altered, reset the BAL preset control.

NOTE This control will only need adjustment at infrequent intervals. Before adjusting the BAL preset control however, ensure that the input lever switch is set to the GND setting.

3.4 SINGLE TRACE OPERATION

1. For single trace operation on the Y1 channel, set
   (a) The MODE switch to Y1.
   (b) The Y1 position control (indicated by double ended vertical arrow) to mid setting.
2. For single trace operation on the Y2 channel set
   (a) The MODE switch to Y2.
   (b) The Y2 position control (indicated by double ended vertical arrow) to mid setting.
3. High sensitivity operation with a bandwidth of dc to 10MHz can be obtained on either channel by pulling the POSITION control which increases the sensitivity 5 times, i.e. 1mV/cm with the sensitivity set to 5mV/cm
   2mV/cm " " " " 10mV/cm
   4mV/cm " " " " 20mV/cm
   Beyond this it is better to revert to normal operation.
4. It is possible to obtain useful higher sensitivities with unspecified overall performance by cascading the two channels. The input signal should be coupled into Y2 and the Y2 OUTPUT socket on the rear panel coupled to the Y1 input using a coaxial connector PL43.

The MODE switch should be set to Y1. The Y2 output provides 0.1V/cm of normal Y2 display, i.e. an additional gain of x20. DC offsets and drift will necessitate the use of ac coupling in this mode and amplifier noise will negate the use of the full sensitivity of 50μV/cm.

3.5 DUAL TRACE OPERATION

In the dual trace condition, the beam switching function is in operation and results in the independent display of two signals simultaneously. Two modes of beam switching – chopped or alternate – are used, selected by the setting of the MODE switch. At any fast setting from 0.2μs/cm to 0.5ms/cm inclusive, the alternate switching mode is recommended. At slow settings from 1ms/cm to 2s/cm, inclusive and EXT X, the chopped switching mode is preferable.

1. For dual trace operation, set
   (a) The Y1 position control to mid position.
   (b) The Y2 position control to mid position.
   (c) Select ALT or CHOP on MODE switch.

3.6 A TIMEBASE OPERATION

The speed of the A timebase is determined by the setting of the A TIME/CM switch. In addition to selection of the speed of the internal timebase, the switch has a functional setting, EXT X in which the internal timebase is inoperative.

The gain of the internal X amplifier may be increased x10 by pulling out the PULL x10 control on the VARIABLE TIME/CM switch. This facility is available at all settings including EXT X. The facility effectively increases the sweep length from 10cm to 100cm and thus allows close examination of any portion of the trace. Any portion of the increased sweep length may be selected for viewing on the display by adjusting the X position control.

A particular advantage of this facility is to increase the maximum sweep speed to 20ns/cm.

1. To adjust the time scale of the horizontal axis
   (a) Set the A TIME/CM switch to the required setting.
   (b) If necessary, adjust the concentric VARIABLE control to reduce the speed.

NOTE The range of the VARIABLE control is approximately 3:1. The VARIABLE control is uncalibrated. At the CAL setting only, the calibration corresponds to the setting of the TIME/CM switch.

Selection of the 2 sec/cm range and full use of the variable control, provides a total sweep time of approximately 1 min.

2. If close examination of any portion of the trace or the fastest sweep rates are required, operate the PULL x10 control.
3. For horizontal shift of the trace, adjust the X position control (identified by horizontal arrow). The control has a dual speed function. Initial operation provides coarse position control, the return adjustment provides fine position control.

3.7 A TRIGGER

The A timebase may be operated in a FREE RUN condition or, more normally, triggered from the positive or negative slope of a signal as determined by the setting of the TRIG SELECT switch. The triggering sources selected by the TRIG SELECT switch are as follows.

(a) The supply line input frequency derived internally from the supply transformer.
(b) Y1 or Y2 amplifiers (irrespective of which beam is displayed).
(c) An external triggering source connected to the A EXT TRIG socket.

The A LEVEL control concentric with the A TRIG SELECT switch, allows selection of the triggering point on the trigger waveform and hence determination of the start of the horizontal trace. When the LEVEL control is set to AUTO, the trigger circuit automatically biases itself to a sensitive trigger level condition. In the absence of a trigger signal in this mode, the timebase will free run and maintain a displayed sweep at the selected speed.

The TRIG SELECT switch is used in conjunction with the A TRIGGER COUPLING lever switch. This switch connects different networks into the trigger amplifier circuit and is effective at all settings of the TRIG SELECT switch.

The operating facilities available at the four settings of the lever switch are as follows.

1. AC Wideband trigger mode used for most common triggering signals.
2. ACF (AC Fast) A filter is switched into circuit to reject low frequencies. High frequency triggering may be effected from complex waveforms such as those with high ripple content or line triggering from a television video signal waveform.
3. TVF (TV Frame) A television sync separator is switched into circuit so that the timebase can be triggered from a television video waveform.
4. DC A wideband trigger mode but it is most useful at very low frequencies. The Y input coupling must also be dc for this mode to be effective on internal trigger.

Triggering control is effected as follows.

1. Set the A TRIG SELECT switch to select the required trigger signal.
2. Set the A TRIGGER COUPLING switch to the required setting.
3. On most waveforms it is convenient to select Auto. If not, adjust the LEVEL control so that the trace starts at the required point on the waveform.

If the timebase is not required to be triggered, set the A TRIG SELECT switch to FREE RUN.

NOTE If, in the Auto mode, the frequency of the trigger is less than approx. 40Hz or the amplitude is too low for reliable triggering, the timebase automatically changes to a free run condition. This condition produces a trace at the selected sweep speed.

3.8 SINGLE SWEEP FACILITY

To set the timebase to give a single sweep

1. Apply a repetitive waveform and obtain a trace with the SWEEP switch in NORMAL by adjusting the A LEVEL control.
2. Move SWEEP switch to SINGLE SHOT.
3. Disconnect input waveform.
4. Move SWEEP switch against the return spring arm and release.

The neon indicator will now light to show that the circuit is primed ready for the next trigger pulse to occur.

5. Apply repetitive waveform. The next trigger pulse will initiate a sweep and the neon will be extinguished. The timebase will not again operate until the SWEEP switch is moved to the ARM position again.

3.9 B TIMEBASE AND TRIGGER

The speed of the B timebase is determined by the B TIME/CM switch, which has all the ranges of the A TIME/CM switch except 2s/cm. The B VARIABLE sweep speed potentiometer is concentric with the TIME/CM switch.

The B TRIG SELECT switch is identical to the A except that there is no FREE RUN position. The B LEVEL is identical to the A except that the AUTO function is taken by the B STARTS AFTER DELAY function. The B TRIG COUPLING switch has AC, ACF, DC positions.

3.10 DUAL TIMEBASE OPERATION – NORMAL DELAYED SWEEP

To examine a small period of a stable 'A' sweep
1. Set the B TIME/CM switch about two ranges faster in speed than the A TIME/CM switch.
2. Rotate B LEVEL control anticlockwise to the switched position, B STARTS AFTER DELAY.
3. Move DISPLAY switch to A INTEN BY B.
4. Adjust preset CONTRAST if necessary to give good visibility of the intensified portion of the trace.
5. Adjust B TIME/CM and the delay multiplier potentiometer so that the intensified portion covers the period of interest.
6. Move DISPLAY switch to B and make final adjustments of delay multiplier potentiometer and B TIME/CM switch.

3.11 DUAL TIMEBASE OPERATION – GATED SWEEP

If the display exhibits annoying jitter
1. Return display switch to A INTEN BY B.
2. Select appropriate trigger source, slope and coupling on the B TRIG SELECT and TRIG COUPLING switches.
3. With the B LEVEL still in the B STARTS AFTER DELAY position, adjust the delay multiplier so that the bright-up starts just before the edge of the waveform selected as a trigger point.
4. Rotate B LEVEL clockwise and adjust for a stable triggering by observing bright-up.
5. Move DISPLAY switch to B.

3.12 DUAL TIMEBASE OPERATION – MIXED SWEEP

This allows expansion of a part of the 'A' sweep while still displaying the 'A' sweep up to the point set by the delay multiplier.
1. Set DISPLAY switch to 'A' and obtain a display using the 'A' timebase controls only.
2. Set B TIME/CM switch two ranges faster in speed than the A TIME/CM switch.
3. Set B LEVEL to B STARTS AFTER DELAY.
4. Move DISPLAY switch to MIXED and adjust the DELAY multiplier potentiometer and the B TIME/CM switch for the best display. The CONTRAST can also be adjusted if necessary to allow for widely differing sweep speeds in the two sections of the trace.

3.13 EXTERNAL X

In this condition, the external signal is applied directly to the internal X amplifier to produce a calibrated (1V/cm) horizontal deflection. Dual trace Y operation may be used if chop is selected. Bandwidth is 5MHz.
1. Set the A TIME/CM switch to EXT X.
2. Connect the external signal to the EXT X socket.

3.14 X-Y MODE

It is possible to use the flexibility of the two Y inputs for XY displays.
1. Set the A TIME/CM switch to EXT X.
2. Set the Y2 input switch to DC or AC.
3. Connect the external signal which is to be used for X deflection to the Y2 socket.
4. Select x10 X amplifier gain.
5. Couple Y2 OUT (rear panel) to EXT X input with a co-axial lead PL43.
6. Operate the Y1 channel as for single trace operation and use the Y2 VOLTS/CM switch to control the X deflection. The Y2 position is inoperative.

3.15 ADDITIONAL FACILITIES

3.15.1 USE OF OPTIONAL PASSIVE PROBE

An x10 passive probe may be used to extend the voltage range and increase the input impedance of the Y amplifiers. The input resistance of a Y channel is 1MΩ shunted by approximately 28pF. The effective capacity of the input lead must be added to this and the resultant impedance will sometimes load the signal source. Therefore it is advisable to use a 10MΩ x10 probe. This reduces the input capacity and increases the input resistance, at the expense of the sensitivity. The probe contains a shunt RC network in series with the input, and forms an attenuator with the input RC of the Y channel. To obtain a flat frequency response it is necessary to adjust the capacitance of the probe to match the input capacity of the Y channel as follows.
1. Set the Y channel VOLTS/CM switch to 20mV/cm, and the A TIME/CM switch to .2ms/cm.
2. Connect the probe to the CAL 1V pin.
3. Set the adjustable capacitor in the probe tip or termination with a small screwdriver for a level response with no overshoot or undershoot visible on the display.

3.15.2 CAL 1V

This pin provides a dc coupled positive-going square wave of 1V ±2% amplitude at approximately 1kHz frequency for calibration checks. The square wave has a source impedance of 200Ω and a rise time of less than 100ns. Shorting the CAL pin to ground will produce a square current waveform of 5mA in the shorting link. This can be used for current probe calibration.

3.15.3 'A' AND 'B' GATE OUTPUTS

These sockets on the rear panel provide a dc coupled positive going square pulse of 10V amplitude from <10kΩ source impedance. The duration of the pulse is coincident with the appropriate time base sweep. Improved rise time may be obtained at the expense of amplitude by resistively loading the outputs.

3.15.4 'A' RAMP

This socket on the rear panel provides a dc coupled positive-going timing ramp of approximately 10V amplitude generated by the 'A' timebase. Source impedance is 4.7kΩ and the ramp may be used as a drive for external frequency swept oscillators to allow display of voltage against frequency.

3.15.5 Z MOD

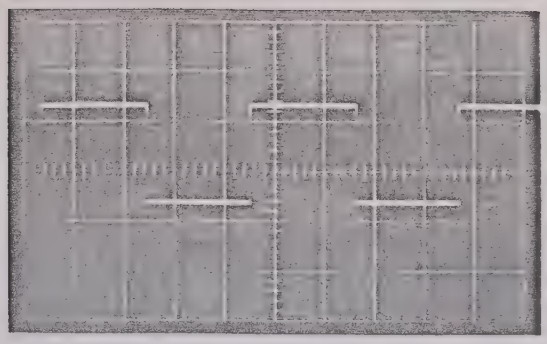
This socket on the rear panel allows dc coupled blanking to be applied to the tube.

The CRT trace is intensified by a negative input, and blanked by a positive input. The required amplitudes are
(a) 2 volts for visible intensity modulation.
(b) +20 volts for blanking at normal intensity.

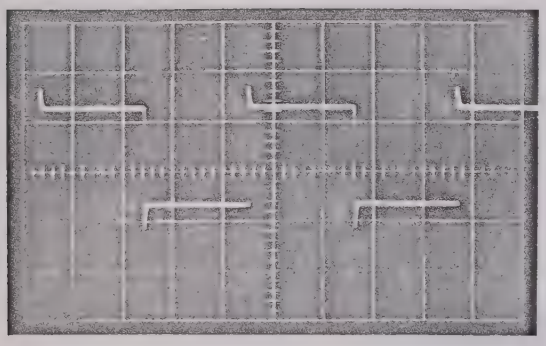
This facility is available in any operating mode of the instrument.

PROBE COMPENSATION

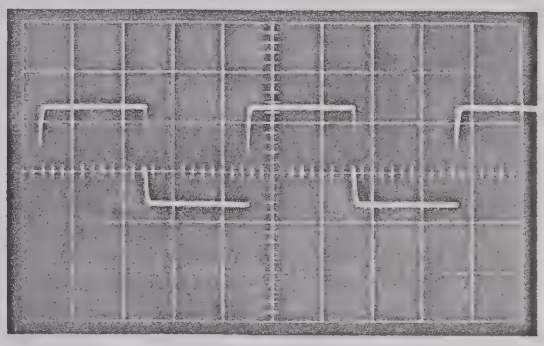
Using CAL 1 V jack on panel
0.5 V/cm Y
5 ms/cm X



Proper Adjustment of Probe Compensating Capacitor

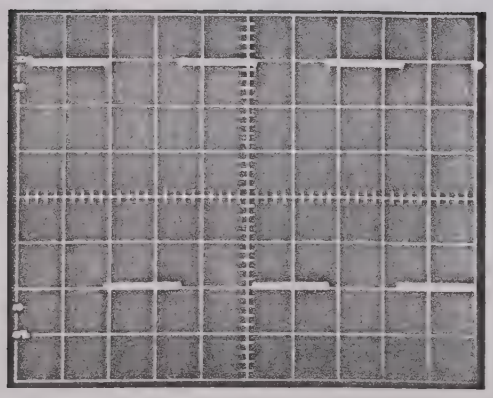


Over Compensated



Under Compensated

Figure 3-1. Probe Compensation



Amplitude/Sensitivity Calibration

Direct input to dc coupled input of amplifiers
Attenuators set at 200 mV/cm

Line Frequency Square Wave from Cal 1 V jack on panel
200 mV/cm Y
5 ms/cm X

Figure 3-2. Amplitude/Sensitivity Calibration

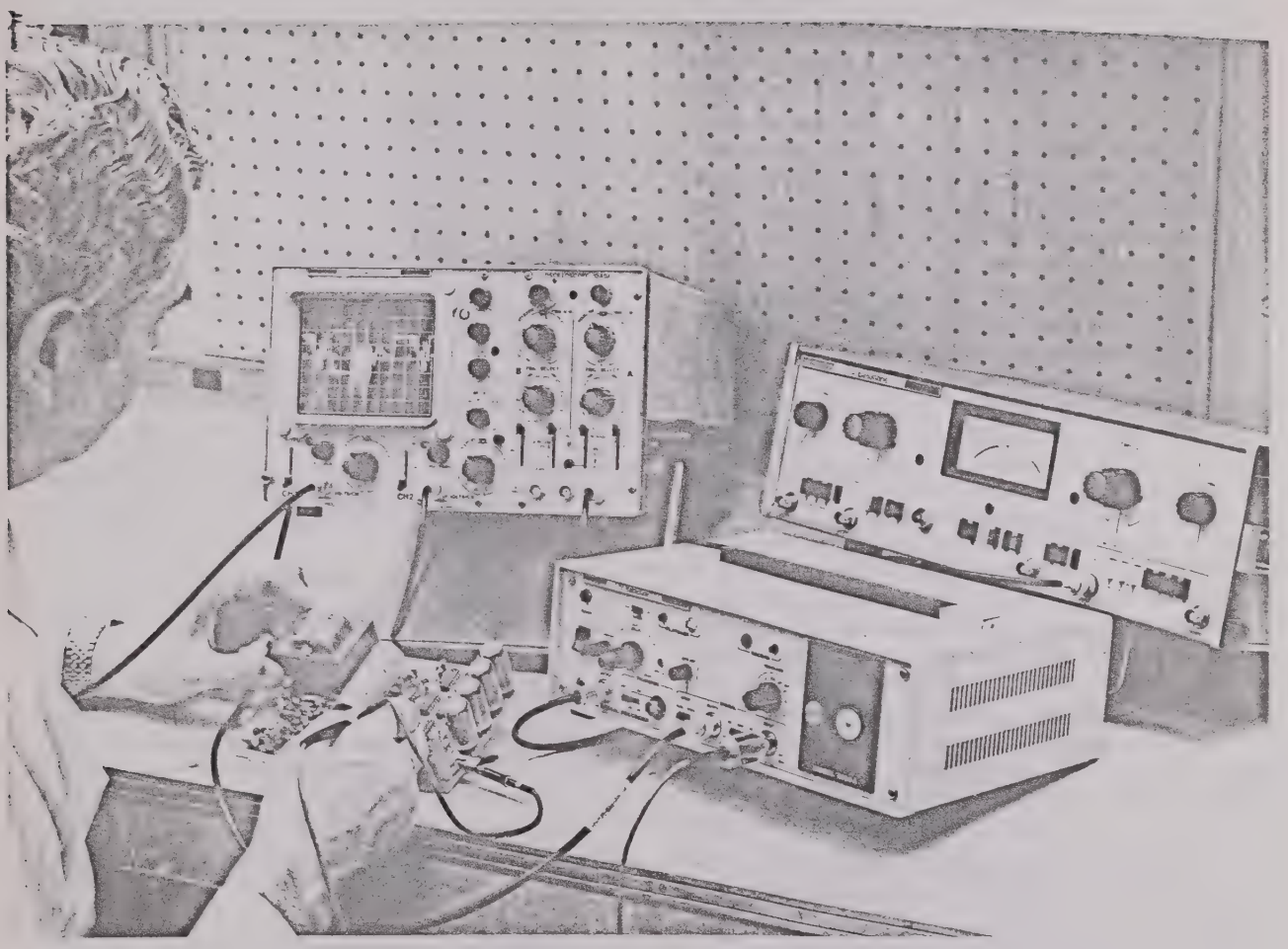


Figure 3-3. Typical Setup Using 7050A Electronic Signal Recorder

For convenience, the circuit reference of any component can be used to determine its location in the instrument.

1	– 99	Frame or interconnection.
100	– 199	Y1 and Y2 Preamplifiers and attenuators.
200	– 299	Beam switch and delay line drive amplifier.
300	– 399	Delay equalizer and Y O/P amplifier.
400	– 499)	'A' Timebase
500	– 599)	
600	– 699)	'B' Timebase
700	– 799)	
800	– 899	Power supply and EHT supply.
900	– 999	Bright up amplifier and X output amplifier.

e.g. R370 is part of the Y output amplifier
D801 is part of the EHT oscillator.

The circuit diagrams are generally arranged for each printed board assembly or group of boards. These diagrams include some of the switches, potentiometers etc., closely associated with the circuit although these components may be mounted on the frame. Consequently not all such components appear on the interconnection diagram fig. 11 and where it makes the circuits easier to follow, some components appear on more than one circuit.

In addition to the relevant circuit diagrams, useful reference can be made to the waveform diagrams, figs. 12 and 13, when following the description of the timebase section.

4.1 THE BLOCK DIAGRAM

The block diagram for the complete instrument is shown in Fig. 1. It is not intended to be a full logic diagram but details the functional points of the circuit and their interrelation. The circuit can readily be divided into two main sections which are the Y and the X deflection circuits. The latter includes the two time bases with their associated trigger systems. The bright-up or Z modulation function is described as part of the time base function.

The main X and Y signal paths for a dual trace display using the main A sweep only, are indicated by the heavy lines.

Y CHANNELS

The switched attenuator, preamplifier and trigger amplifiers are identical for the two Y channels. Y2 differs in having invert and output facilities. The state of the decade steps of attenuation and 1, 2, 5 sequence of preamp gain switching are determined by the sensitivity selected.

The use of the x5 GAIN on each channel increases their basic sensitivity to 1mV per centimeter but reduces the overall bandwidth to 10MHz.

The channel switch is a fast electronic switch with the equivalent of a changeover action as shown. It selects either the Y1 or the Y2 signal to be passed to the subsequent stages and is controlled from a bistable. In the chop mode the bistable is driven by continuous pulses from the free running multivibrator, switching the beam between the Y1 and Y2 signals as the X sweep progresses. In the alternate mode, the multivibrator acts as a monostable generating a single pulse to reverse the beam switch at the end of each time base sweep, giving alternate Y1 and Y2 sweeps. In the ADD mode, both the Y1 and Y2 switches are closed and the two signals are summed algebraically. On Y1 or Y2 only the appropriate switch is closed allowing that signal to pass.

The signal from the selected channel is passed via a delay line and amplifiers to the Y deflection plates of the CRT. This delay allows examination of that point in the waveform which initiated the sweep because the deflecting signal reaches the Y plates after the time base sweep has been initiated and the trace brightened.

THE TIMEBASES

The purpose of the timebase system is to generate a linear ramp or ramps to deflect the spot in the X direction. The trigger system initiates each sweep from the incoming or other signals, normally to obtain a stationary display of a repeated waveform.

TIMEBASE 'A' OPERATION ONLY

The internal or external signal as selected is amplified by the trigger amplifier to drive a trigger circuit. If the timebase is ready to commence a sweep, a transition of the trigger circuit will set the 'A' timebase bistable which in turn initiates the 'A' ramp. This signal is passed through the X gate and X output amplifier to the X deflection plates of the CRT. At the end of the sweep, when the ramp reaches the required level the bistable is reset, returning the ramp to its original level. During the period of sweep the trigger gate is prevented from passing trigger pulses to the bistable and this inhibition is maintained by the hold off circuit until the ramp generator is fully recovered, ready for the next sweep to commence on the next trigger pulse, when the cycle repeats.

The bright-up amplifier normally holds the CRT beam in the cut off state. The output of the 'A' bistable which allows the 'A' ramp to operate, also feeds the bright-up amplifier to raise the intensity of the CRT spot to the level determined by the intensity control.

At the end of sweep, this output of the bistable is reset and blanks the trace during the flyback period.

If the Y channels are being switched in the chopped mode, the differentiated output of this multivibrator is also fed to the bright-up amplifier to blank the trace while the Y switching transition takes place. This leaves the appearance of two separate traces for Y1 and Y2 on the screen unless the sweep speed is higher than that normally recommended for chop operation.

'A' INTENSIFIED BY 'B' ('B' starts after delay)

In this mode operation of the 'A' ramp is the same as for 'A' only. The 'B' timebase bistable is switched on at the required point in the 'A' sweep when the 'A' ramp reaches the potential set by the delay control detected by the comparator. The 'B' ramp generator then runs either for its full period or until the end of the 'A' ramp, whichever occurs first, when the 'B' bistable is reset. The 'B' single shot bistable ensures that there is only one 'B' sweep during any 'A' sweep. The output of the 'B' bistable drives the bright-up amplifier to brighten the 'B' portion of the 'A' trace above the normal level, the relative level of the normal to brightened portion being determined by the contrast control setting.

'A' INTENSIFIED BY 'B' – GATED

In this mode the operation is as outlined for the normal intensified mode except that the output from the comparator only opens the 'B' timebase bistable trigger gate, allowing the next 'B' trigger pulse to trigger the bistable and hence initiate the 'B' ramp.

'B' ONLY

In this mode, the 'A' and 'B' sweeps are triggered and run as in the intensified mode. However, the X gate allows only the 'B' sweep signal to the X amplifier as the deflecting signal. The resultant display is then that section brightened up in the previous mode, now expanded to the full screen width. In this mode, the trace is only brightened during the 'B' sweep.

MIXED 'A' AND 'B'

This mode is a combination of the 'A' and 'B' modes. The 'A' sweep is triggered and runs as normal until the 'B' sweep starts as in the intensified or 'B' modes. During this time the 'A' ramp is fed via the 'B' ramp generator to the X gate to deflect the trace. This 'A' ramp connection also ensures that the 'B' ramp generator starts from the correct point. When the 'B' bistable is energised, the 'B' ramp runs, starting from the 'A' level at that instant and this ramp is passed by the X gate to increase the sweep speed to the 'B' rate. When the 'B' ramp reaches the normal end of sweep level, the 'B' timebase bistable is reset, in turn resetting the 'A' timebase bistable allowing the cycle to repeat after the 'A' hold off period.

The bright-up circuit operates as in the 'A' intensified by 'B' mode, allowing the contrast control to be used to equalise the brightness of the 'A' and 'B' portions of the trace despite the differing sweep speeds.

TRIGGER MODES

The trigger signal for either time base, selected from internal, external or line frequency sources, is ac or dc coupled before being fed into the trigger amplifier which is biased by the required trigger level and the resultant output passed to the trigger circuit to be squared up.

In the FREE RUN mode, the 'A' trigger gate is permanently energised and the 'A' timebase bistable is set again at the end of each hold-off period.

When AUTO coupling is selected, the 'A' trigger amplifier is automatically biased to the optimum working point for sensitive operation of the trigger. If the signal level out of the trigger amplifier is insufficient to operate the trigger circuit, a further output from the auto circuit causes the 'A' timebase to free run, displaying the necessary bright line trace.

When TV Frame coupling is selected for the 'A' timebase, a synch. separator circuit is introduced into the signal path and the A timebase is triggered by each frame pulse.

In Single Sweep, the relevant bistable normally inhibits trigger pulses from reaching the 'A' timebase bistable. When the single shot bistable is set manually, the trigger gate is opened and the next trigger pulse initiates a sweep. When the sweep starts the single sweep bistable is reset, preventing the timebase from sweeping more than once.

THE EXTERNAL X I/P

When external X is selected, the trace is brightened and the timebases are inhibited. The amplified X input signal passes through the X gate to the main amplifier.

4.2 INPUT ATTENUATORS AND PREAMPLIFIERS

NOTE The Attenuator and Preamplifiers in the Y1 channel are identical to those in the Y2 channel. Accordingly, only the Y1 channel is described. Where a corresponding component carries a different number in Y2, this number is shown in brackets after the Y1 number.

The input signal is applied from the front panel socket SKY to the 3 position lever switch, S10. When the INPUT COUPLING SWITCH is in the DC position, the input signal is coupled directly to the Input Attenuator stage. In the AC position, the input signal passes through C155. This capacitor prevents the dc component of the input signal from passing to the amplifier. The GND position opens the signal path and connects the input circuit of the amplifier to ground. This provides a ground reference without having to disconnect the applied signal from the input connector.

The input attenuators are frequency compensated, voltage dividers. For dc and low frequency signals they are primarily resistance dividers and the attenuation is determined by the resistance ratio, the effect of the capacitors being negligible. However, at high frequencies, the reactance of the capacitors decreases and the attenuator becomes primarily a capacitive divider. Each attenuator contains an adjustable series capacitor to provide optimum response for the high frequency components and an adjustable shunt capacitor to set up the input capacity of each section. The component values in each section are arranged to provide the required attenuation and present the same RC characteristic for all settings of the VOLT/cm switch.

Two attenuator sections are employed giving an attenuation of 10 or 100 respectively. These are used singly or cascaded. The basic amplifier provides a maximum sensitivity (for full bandwidth) of 5mV/cm; gain switching in the amplifier reduces this to provide the 10mV/cm and 20mV/cm settings. The x10 attenuator is introduced to provide the 50, 100 and 200mV/cm ranges; the x100 to provide the 500mV, 1V, 2V/cm ranges and the x100 and x10 cascaded to provide the 5, 10 and 20V ranges.

The x10 attenuator consists of R176 and R177. Capacitor, C165 adjusts the input capacitance on the 50, 100, 200mV/cm ranges, while C167 corrects the frequency response of the attenuator.

The x100 attenuator consists of R163 and R169. Capacitor C159 adjusts the input capacitance on 500mV, 1V, 2V/cm ranges, while C161 corrects the frequency response of the attenuator.

Capacitor, C171 provides adjustment for the input capacity when the attenuators are not in circuit. R187 determines the input resistance of the oscilloscope when the attenuators are not in circuit and contributes to the attenuating resistors on all other ranges.

The output from the attenuator is taken via the input current limiting resistor, R189, to the input stage consisting of a pair of matched field effect transistors, TR101 and TR102, operating as source followers.

The signal input is fed to the base of TR101 and the balancing potentials to the base of TR102; since these transistors are matched and coupled thermally, any drift due to temperature changes will be minimized.

The field effect transistor gives a high input impedance which does not shunt the attenuator. The signal excursion at the gate of TR101 is restricted by the limiting diodes, D101 and D102, which are returned to positive and negative potentials of approximately +6V and −6V, determined by the zener diodes, D103 and D104.

The input stage drives a pair of emitter followers, TR103 and TR104, to provide a low impedance drive to the following stage.

The output from the emitter followers is applied to the long tail pair amplifier, TR121 and TR122. TR120 being a constant current source of this stage. The stage provides a nominal gain of about 5, the emitter circuit however contains the FINE GAIN CONTROL, R10 (R20), which allows a reduction in gain of at least 2:5:1. The two transistors in this stage are matched and thermally coupled together in order to reduce drift to a minimum. In addition, they are mounted on the rear screen of the attenuator assembly in close proximity to the FINE GAIN CONTROL. This ensures that the length of the emitter leads to the gain control and consequently their inductance is kept to a minimum.

A potentiometer, R123, is provided in the emitter circuit giving some variation of the collector currents. This allows the emitter potentials of the following stage to be equalised to prevent trace movement when gain switching.

The collector supply is stabilised by the 5.6V zener diode, D121, giving a collector potential of +4V. This provides sufficient margin to allow for variations of input dc level due to the possible range of FET source to gate voltage.

The following stage is also a long-tailed pair with gain switching incorporated into the emitter circuit.

In the minimum gain condition the gain is determined by the emitter resistors, R132 and R134.

The gain is raised by x2 and x4 by connecting between the emitters network, R137 and R138, or network, R135 and R136, respectively.

The two trimmers, C122 and C123, provide a high frequency compensation to equalize frequency response between ranges.

Decoupled resistors, R154 and R155, are added to reduce collector dissipation and keep drift due to thermal effects to a minimum.

The collector supply is stabilised by the 5.6V zener, D122.

The final stage on this board and on the attenuator assembly is a pair of emitter followers, TR125 and TR126.

The trigger signal is taken directly from the emitters but the signal for the remainder of the Y amplifier is tapped down the emitter loads by the addition of a small series resistor. This allows a dc shift of the output to be provided for, balancing in the following stage by the addition of the potentiometer, R146, in the bottom end of the emitter loads.

The signal outputs from this stage represent approximately 25mV/cm of screen deflection, the dc level being nominally +7.5 volts.

The signals are then passed to the Beam Switch printed circuit board, in the case of Y1 direct but in the case of Y2 via the INVERT SWITCH, S201.

4.3 BEAM SWITCH

The Y1 and Y2 signals feed to the beam switch printed circuit board into two identical long-tail pair amplifiers, TR203/4 and TR205/6. Each amplifier provides a number of additional functions, namely:

1. SHIFT CONTROL is obtained by means of potentiometers, R26 and R27, in series with the emitter resistors of each stage.
2. Overall gain adjustment of each channel is provided for by means of the two networks, R226/R227 and R231/R232.
3. The maximum sensitivity of both Y1 and Y2 channels can be increased to 1mV/cm, this requires that the gain of these stages is increased by five times and is achieved by shunting across the emitter circuit the network, R228/R229 for Y1 and R233/234 for Y2. The switch for this function is mounted on the rear of the respective position controls.
4. Networks, R230/C202 and R235/C206, are included to allow the h.f. response of the two channels to be matched.

The signals from this pair of amplifiers are fed to the beam switch circuit consisting of eight diodes, D201 to D208 inclusive. The switch is operated by signals applied in antiphase to points 26 and 29 from the Beam Switch Bistable. The signal level at these points switches from approximately +7V to approximately +0.3V. Thus when point 26 rises to +7V diodes, D201 and D202, are cut-off and diodes, D203 and D204, are turned on allowing Y1 signals to pass to the following stage. At the same time, point 29 will be at approximately +0.3V allowing D205 and D206 to conduct and prevent Y2 signals reaching the following stage. When the potentials on points 26 and 29 reverse, Y2 signals will pass to the following stage and Y1 signals will be blocked.

The output from the beam switch network is taken to transistors, TR210 and TR211, connected as shunt feedback amplifiers with R249 and R250 providing feedback from the collector to base of the respective transistor. Provision is also made in this stage by means of A.O.T. resistors, R294/R295, to take out small unbalances which cause excessive trace movement when switched to the ADD mode. Also in the ADD mode it is necessary, since two stages are now connected to a common load, to remove half the resultant current in the load, this is achieved by returning R245 and R246 to the −15V line when switching to ADD.

Signals from this stage pass to the delay line driver, a further long tail pair, TR212/TR213, fed from a constant current source, TR214. A current of 10mA per side is common to this stage and, via the delay line, to the delay line terminating stage.

The Beam Switch Bistable consists of transistors, TR215 and TR216, the conducting state of these determining which channel is displayed. For single trace operation, either of the emitters is grounded via points 35 and 36. For dual trace operation, both emitters are grounded and the transistors are turned on or off by pulses from TR217 routed via capacitors, C213 and C218, and diodes, D212 and D211. In the ADD mode both emitters are open circuited raising both collector voltages and hence opening both diode gates.

The chop multivibrator contains transistors, TR217 and TR218, which operate as an emitter-coupled astable multivibrator whose frequency of approx. 500kHz is determined by R280, R285, and C221.

In addition to operation for the chop function, the circuit acts as a monostable when the alternate mode of beam switching is selected. In the alternate mode, the circuit produces 1 pulse per timebase sweep and is fed with an end of sweep pulse from the time base bistable. The −15V volts supply is connected to point 32 via the FUNCTION SWITCH, this increases the current through TR218 and causes a drop in the level of the collector voltage.

This drop cuts off TR217. The negative going end of sweep pulse thus finds the circuit in a monostable condition which it triggers producing a high amplitude positive-going pulse at the collector of TR218 and a negative-going pulse at TR217. The output from TR218 is taken to the Bright-up Amplifier to blank the trace during the chop transistion period and that from TR217 to the Beam Switch Bistable.

4.4 DELAY LINE AND DELAY LINE EQUALIZER

The Delay Line is of the printed circuit type and introduces a signal delay of approximately 95ns. This time allows for delay in the time base and bright-up circuits and ensures that the first part of a signal is visible.

The output of the delay line is terminated by the resistors, R301 and R302, and feeds into the common base stage, TR300 and TR301.

The pulse response for the uncompensated delay line can be represented by a fast rise for about 50% of the amplitude followed by a considerably longer rise to full amplitude. Correction for this response is provided in the following stage, TR302/TR303, by means of resistance/capacitor networks, R308/C302, R309/C303, R310/C305, R311 and C306, connected between the emitters.

A further stage, TR304/TR305, provides additional frequency compensation (C310, C311, R324/C312) and raises the signal to the required level to drive the output stage.

4.5 OUTPUT STAGE

The output stage consists of four transistors, TR351, TR352, TR353 and TR354, operating as a differential cascode amplifier. The collector loads are made up of four resistors in series/parallel in order to give the required dissipation with minimum stray inductance and capacitance. High frequency compensation is provided by the inductances, L351 and L352.

A constant current transistor, TR355, gives a current in each side of the output stage of approximately 35mA and holds this stable against small variations of the dc input level of +7.25V. At this current the nominal mean Y plate potential is +55V.

4.6 Y TRIGGER AMPLIFIERS AND Y2 OUTPUT AMPLIFIER

Incorporated on the Beam Switch printed circuit board are the Y1 and Y2 trigger amplifiers and the Y2 output amplifier stage.

The trigger amplifiers consist of long-tail pairs, TR201/TR202 and TR207/TR208, receiving differential signals from the Y1 and Y2 pre-amplifiers and providing a single ended output for the Time Base.

R213 and R223 provide a means of setting the d.c. level for the trigger circuits (nominally 0V).

In addition a further output is taken from the Y2 trigger amplifier and fed to an amplifying and inverting stage, TR209. This provides an output level of 100mV/cm and when used in conjunction with the X amplifier, gives an X-Y operation facility.

The gain of this stage can be set by R238 and phase shift correction is provided by C228 connected across the feedback resistor, R242.

4.7 "A" TRIGGER SELECTION AND AMPLIFICATION

Trigger sources (Y1, Y2, Line, Ext) are taken to S40AF. The internal trigger signals are brought via 50Ω coax, and are terminated by R400 and R406. The line trigger signal is provided from a single turn secondary winding on the mains transformer and the correct trigger voltage is obtained by the simple attenuator, R405 (mounted on S70) and R746. External trigger signals are attenuated approximately fifty times by the network, R401, C400, R402 and C401. The signal selected by S40AF is passed via the trigger coupling switch, S42, to two cascaded emitter-follower stages, TR409 and TR410. D406 and D407 provide the necessary protection against excessively large external trigger signals. The signal from the emitter of TR410 is switched by S40BF and S40BB, according to the selected trigger slope, to the base of TR413 or TR414 which form a long-tailed pair amplifier. S40BF, S40BB also connect the undriven base of this amplifier to the network, C451, R437, and R420, which provides a low impedance path to ground for high frequency signals and the correct bias to balance the amplifier. The trigger level control (R440) also acts on this network via R441, introducing a positive or negative offset, which is thus mixed with the amplified trigger signal.

The network, R422 and C415, between the emitter of

TR413 and TR414, provides high frequency compensation. The output from TR414 is applied to the base of TR415 which together with TR416, forms another long-tailed amplifier; R488, R490 and C424 provide high frequency compensation. The base of TR416 is normally held at a fixed bias by zener diode, D423, except when S41b (the auto level switch) is open (see Auto operation). When the level control (R440) is adjusted so that the base potentials of TR413 and TR414 are equal, R453 adjusts the dc potential on the base of TR415 so that the Schmitt trigger circuit is brought near its switching point, maintaining the same trigger level for positive and negative slope selection.

The output from the collector of TR415 is taken via D402 (See trigger signal routing) to grounded-base amplifier, TR404, and from the collector of this transistor via D415 to the Schmitt trigger circuit. The output from TR416 collector is connected to the auto level circuit, and the TV sync separator circuit.

4.8 AUTO

When auto is selected by turning the 'A' trigger level control to its extreme anticlockwise position, S41a and S41b open. R491 and the base of TR416 are disconnected from the zener diode, D423, so that the dc potential set by R453 has little effect on the amplifier, TR415 and TR416. The opening of S41 causes the potential at the extreme anticlockwise end of the level control to change from −15V approx. to 0V approx. (R440 and R552 form a potential divider across the ±15V lines). Thus the amplifier, TR413/TR414, is still approximately balanced. S41a also operates on TR403 (see Trigger signal routing) to energise the bright-line circuit. (See Free run and bright-line circuit). Trigger signals from the collector of TR416, are coupled via C411 and C412 to the bases of the complementary amplifier stage, TR406 and TR407. Emitter resistors, R426 and R427, define the gain, and C442 and C443 provide high frequency compensation. Both transistors are normally biased off but are sensitive to small input signals with one or the other being turned on. The output resultant from the commoned collectors is an amplified form of the input which is not paralysed by inputs of widely differing mark/space ratio. It is applied via D416 to grounded base stage, TR404, and thence to the Schmitt trigger.

4.9 T.V.

Trigger signals from the collector of TR416, are taken via R447 and C445 to the base of TR408. When the trigger coupling switch, S42, is set to select TV operation, current is allowed to flow into the base of TR408, and the collector load, R449 and R448, is connected to the +15V line. A TV video waveform, with positive-going sync. pulses, applied to the base of TR408 will cause base current to flow and charge up C445, biasing off TR408 on all but the most positive (sync. pulse) part of the signal. The collector voltage waveform is thus composed only of the line sync. signal. The low pass filter, R449 and C416, extracts the frame pulse information from this waveform, to be applied via D413 direct to the Schmitt trigger input.

4.10 "A" TRIGGER SIGNAL ROUTING

The three different trigger circuit connections, manual trigger, auto and TV frame,are controlled by the state of TR403/TR405, and the position of the trigger coupling switch, S42. In manual operation, S41a is closed and with no voltage across its base resistor, R552, TR405 is cut off. Current through R439 and R421 turns on TR403 causing its collector potential to become approximately −15V. Current through R424 and D410, pulls the collector potentials of TR406 and TR407 negative, cutting off D416, and disconnecting the auto circuit output from the grounded base amplifier, TR604. Current through R418 acts on the bright-line circuit (see Free run and bright-line circuit), to prevent it operating. Trigger signals from TR415 are passed to the Schmitt trigger as current from TR415 flows through D402 into TR404, and from the collector of TR404 via D415 to the Schmitt trigger.

When Auto is selected, S41a is open, base current through R552 bottoms TR405, and this in turn cuts off TR403. Current through R408 and D435 causes the collector of TR415 to go negative, cutting off D402. At the same time, the current through R424 and D410 is removed allowing the collector potentials of TR406 and TR407 to rise, turning on D416. Trigger signals now pass from the collector of TR416 to the auto circuit, TR406 and TR407, and then via TR404 to the Schmitt trigger. Also, when TR403 is cut off, current through R418 is removed, energising the bright-line circuit, TR411 and TR412, and diode D404, is turned on by current flowing through R422 enabling the Schmitt trigger output waveform to drive C407. (See Free run and bright-line circuit).

With the trigger coupling switch in the AC, ACF or DC positions, the junction, R446/R492, is connected to −15 volts, and the junction, R492/R448, is held negative with respect to ground, cutting off D413. The Schmitt trigger circuit takes its input through D401 from TR404.

When TVF is selected, the junction, R446/R492, is disconnected from −15V allowing current to flow into the base of TR408 through R446. R419 is connected to −15V pulling the collector of TR404 negative and cutting off D401. The normal trigger signal path is therefore interrupted and a TV frame waveform on C416 will bias on D413 and be connected to the Schmitt trigger input.

4.11 "A" SCHMITT TRIGGER

This consists of TR401, TR402 and associated components. When the base of TR401 is negative with respect to ground, TR401 is off and TR402 is on.
R471 and R416 bias the base of TR402 about 0.5 volt positive. When the base voltage of TR401 is driven positive it will start to conduct. R416 provides positive feedback causing a rapid transition to the opposite state with TR401 conducting and TR402 cut off. When the base of TR401 returns negative, the switchover will occur at a lower level because of the change in potential across R416. This backlash prevents the trigger from responding to low level noise when biased to its operating point.

C404, R414 and C405 provide high frequency compensation of the feedback network. The output from the collector of TR402 is differentiated by C420 to operate the timebase bistable, and also via D404 and C407 to the bright-line circuit as follows.

(a) FREE-RUN AND BRIGHT-LINE CIRCUIT

When Free run is selected by S40, −15V is connected to pin 9, and TR403 and TR405 are cut off by diodes, D403 and D405.

In turn, TR411 is cut off and the negative movement of its collector is passed by emitter-follower, TR412, to R462.

Current in R465 is switched from D419 into D420 and D421 to the base of TR419, turning on the timebase bistable. At the end of the sweep the hold off current from R458 will exceed that from R465, turning off the bistable for the hold-off period.

At the end of the hold-off period, the base of TR419 goes negative and the timebase bistable is again turned on. The cycle repeats as long as Free Run is selected.

When Auto is selected, TR405 is turned on, turning off TR403 and causing the time base to free run as above. When trigger signals are received and operate the Schmitt trigger, trigger pulses are routed from the Schmitt to the base of TR411. The negative transition of the collector of TR402 is transferred by D404, C407 and D415 to the base of TR411. As this transistor turns on, the rise of its collector potential is transferred via TR412, D418 and C418 in a regenerative loop to its emitter, so that TR411 bottoms, and the emitter of TR412 follows. This action inhibits the free run bias from R465 to the time base bistable and is maintained for approx 40ms, determined by C418 and R430. If no further trigger pulse is received in this period, the system will return to its free run condition. However, the regenerative action caused by any trigger pulse can be initiated at any point in the discharge of C418, and when the time base is being triggered at medium and high frequencies, the system is permanently biased in the condition which allows normal triggered operation.

4.12 "A" TIMEBASE BISTABLE

TR419 and TR420 form the emitter-coupled trigger bistable. R470 normally biases on TR419 and the low potential across R479 holds off TR420.

A negative transition from the Schmitt trigger is coupled via C420 and D421 to turn on TR419. The positive movement of the collector of TR419 is transferred by R479 to hold on TR420 and the bistable is reversed.

The collectors of TR421 and TR422 provide the two buffered outputs from the bistable. TR421 provides the "A" bright-up current pulse to the bright-up amplifier. The alternate beam switching pulse is provided from TR422 via C432 and emitter-follower, TR430. When TR420 is turned on, its collector potential falls and the diode, D422, conducts to initiate generation of the "A" ramp as described in section 4.13. The effect is that the emitter of TR432 goes negative until D431 is brought into conduction when TR420 is turned off and the bistable reverts to its initial condition, ready for the next trigger pulse via D421.

4.13 "A" RAMP GENERATOR

The basic ramp generator is the bootstrap feedback circuit formed by F.E.T., TR426, as a source-follower with two subsequent emitter-followers, TR427 and TR428. The base-to-emitter voltages of these two transistors are approximately equal and opposite so that the emitter of TR428 follows any change of gate voltage on TR426 with an offset which is the gate to source voltage of TR426, plus the potential across R514. The current in TR426 and hence the voltage between its gate and the base of TR427, is held constant, independent of actual potential as this current is the collector current of the grounded-base transistor, TR435.

Consequently there is a constant voltage across the selected timing resistor, Rt which in the absence of other influences, flows to ground through the selected timing capacitor Ct causing the voltage across this capacitor to drop linearly. This linear ramp, appears similarly on the emitter of TR428, is transferred to the emitter of TR432 and goes via the diode gate, D432 and D433, to the X gate. It is also tapped off via R547 to the 'A' ramp output amplifier, as described in section 4.21.

The sweep speed, that is the ramp slope, is determined by the values of Ct and Rt which are selected for a particular range. Details of this range switching is shown in fig. 5.

The third factor to control the sweep speed is the gate-to-source voltage of TR426. This F.E.T. is matched in characteristics with TR425. As both devices carry the same current, being coupled via the grounded base transistor TR435, and as R512 is equal to R514, the voltage between the gate of TR426 and the base of TR427 is equal to the voltage between gate and source of TR425, plus the voltage across R512. The latter voltage sum is set by resistor network, R511, R508 and R509, together with the preset calibration control, R510, and the variable sweep speed control, R507.

During the flyback period when the time base bistable is reset, D422 is biased off and current flows through R540 into the emitter of TR431 and so to D429. This current is much greater than the current through Rt, so that the timing capacitor Ct is charged rapidly positive, and the emitter of TR428 follows until it approaches zero potential. At this point, TR429 conducts, diverting current from TR431. This subsequent reduction of the current in D429, limits when it balances the current through Rt. This is the quiescent point of the ramp generator with the emitter of TR428 and the collector of TR435 approximately at zero, and the voltage on the gate of TR426 at +4V. When the timebase bistable is switched by a trigger pulse, D422 is turned on, removing completely emitter current from TR431 and reducing the current in D429 to zero. The normal ramp action then takes place with the constant current through the timing resistor, Rt negatively charging

the capacitor, Ct. The capacitor charges linearly until the emitter of TR432 is at about −4V, when D431 conducts to reset the timebase bistable and complete the cycle.

4.14 HOLD-OFF

Triggering of the timebase bistable must be prevented or held off during the flyback period until the ramp generator has fully returned to its quiescent state. When a trigger pulse switches the timebase bistable, TR419/TR420, the collector potential of TR422 goes positive and, acting through R560, D440 pulls the base of TR417 positive. This causes current to flow from TR417 through D443, presenting a low impedance path to ground to inhibit trigger pulses through C420. The capacitor, C_{HO} (representing the next smallest timing capacitor in the timing series Ct) is charged negatively by the negative-going ramp on the emitter of TR432, via gate, TR423/D425/D426. TR423 is only turned on by the timebase bistable during the sweep, via R481, and ensures that C_{HO} starts to charge immediately the ramp is initiated.

As C_{HO} charges negative, TR418 is cut off and the current in R466 flows through D442 as a second source to cause TR417 to conduct. At the end of sweep when the timebase bistable is reset, the collector of TR422 returns to ground, cutting off D440, and TR423 is cut off removing the charging current from C_{HO}. Current through R468 slowly discharges C_{HO}.

While the sweep generator is in its flyback period, C_{HO} holds TR418 cut off, leaving TR417 in conduction to inhibit trigger pulses into the timebase bistable. After the ramp generator has reached its quiescent condition, C_{HO} discharges sufficiently to allow TR418 to conduct and cut off TR417, allowing D421 to conduct on the next trigger pulse to initiate another sweep.

4.15 SINGLE SWEEP

This part of the circuit is based in IC400, a quad gate TTL integrated circuit connected to form two bistables. Gates, a and b, form a bistable to store the arm signal from the single sweep switch, and gates, c and d, form a bistable which acts on the hold-off circuit of the 'A' timebase to prevent trigger. When the single sweep switch is moved from NORMAL to SINGLE SWEEP, S44a grounds input 5 of IC400b. As R517 holds input 10 high, the bistable settles with 8 low and 6 high. The switch, S44b, removes the positive potential from R533 allowing R530 to turn off TR418 via D424, simulating the hold-off signal (see section 4.14) to inhibit trigger pulses. When the switch is moved to ARM position, S44a grounds input 10 and the state of bistable, IC400a/IC400b, is reversed. As output 6 goes low, this negative transition is coupled through C437 and D427 to input 2 of the second bistable. This switches over and input 3 goes high, cutting off D424 and removing the hold-off condition. Then a trigger pulse is able to trigger the bistable and a normal sweep is executed. At the end of sweep, the timebase bistable resets, generating a negative-going pulse on the emitter of TR430 which is coupled to input 12 by C436 and resets the second bistable. Output 3 goes low again, turning on D424, to reinstate the hold-off and prevent further sweeps. When the single sweep switch is returned to the SINGLE SWEEP position, before, during or after the sweep, the first bistable is reset, ready for the cycle to be initiated again after the sweep is complete. The action of this bistable avoids possible multiple triggering due to contact bounce of S44A since this switch must re-make to the SINGLE SWEEP position before the ARM condition of the bistable is removed. TR443 controls the neon indicator lamp, N400, to indicate the state of the second bistable.

4.16 COMPARATOR AND "B" SINGLE TRACE BISTABLE

TR615, TR616, TR614 and TR617 form the comparator which operates on the "A" ramp to define the delay period. Assuming D608 is cut off, (TR620 on) the comparator functions as follows:– The bases of the long-tailed pair, TR614 and TR617, are driven from the "A" ramp and the delay potentiometer, respectively. R745 ensures that the starting potential of the "A" ramp is more positive than that on the wiper of the delay multiplier potentiometer. Thus current initially flows more in TR614 rather than in TR617, biasing the second long-tailed pair, TR615/TR616, with TR615 on and TR616 off. The collector current of TR615 biases D633 into conduction to present a low impedance to "B" trigger pulses applied through C620, and prevents the triggering of the "B" timebase bistable, TR612/TR613.

At the point in the "A" sweep determined by the setting of the delay control potentiometer, R744, the base of TR614 becomes more negative than that of TR617, and so the bias on the input of the pair, TR615/TR616, is reversed, and TR615 is turned off. This removes the current through D633, and allows the reset trigger pulse through C620 to trigger the "B" timebase bistable. Alternatively, if S71 is closed for 'B starts after delay', the bias of R663 acts as a trigger pulse to start the "B" sweep immediately. TR620 and TR621 form the "B" timebase single trace bistable. In the 'A only' position, R699 is pulled negative so that D612 is cut off. The collector potential of TR621 is near zero, TR620 is turned off, and current flows through R691 (the comparator) such that TR615 remains on, independent of the state of TR614 and TR617. This stops the "B" timebase bistable triggering in the 'A only' condition.

In all but the 'A only' position of the display switch the collector resistor of TR621, R699, is connected to approx. +15V and the bistable can function.

At the start of the "A" sweep, a negative pulse from the "A" timebase bistable (B enable) is applied through C630, turning off TR621 and turning on TR620, to reverse bias D608 and allow the comparator to operate. When the "B" timebase bistable is triggered, the collector of TR613 goes negative and this transition is coupled via R676 and diode D611, to turn off TR620, resetting the "B" single trace bistable. D608 again conducts to override the comparator action and so inhibit further triggering of the "B" timebase.

4.17 "B" TRIGGER AND RAMP GENERATION

The "B" trigger amplifier, Schmitt trigger, timebase bistable and ramp generator are very similar to their "A" timebase counterparts. The following description is brief and reference to the equivalent component in the "A" circuit is shown in brackets.

The "B" trigger source is selected by S70 from Y1, Y2 or LINE which are each common to the "A" and "B" timebases. The "B" ext. trigger is separate and is derived from the attenuator of approximately 50:1 consisting of R614, R615, C601 and C602. The selected signal is taken to emitter-followers, TR605 and TR606 (TR409 and TR410), and then to the long-tailed pair, TR607/TR608 (TR413/TR414) via the polarity switch, S70d and S70c. The level potentiometer, R631 (R440), determines the potential on the undriven side of this amplifier. The amplified signal is taken to the second long-tailed pair, TR609/TR610 (TR415/TR416). The output of this amplifier drives direct to the Schmitt trigger, TR601 and TR602 (TR401 and TR402).

The trigger pulses generated by the Schmitt trigger are coupled via C620 and D604 to the base of TR612 (TR419) which together with TR613 (TR420), forms the "B" timebase bistable. The action of the comparator in gating trigger signals into the bistable is already described in section 4.14.

A trigger pulse allowed through the gate turns off TR612 and TR613 on. The 'B' ramp generator will now run until the negative-going ramp on the emitter of TR629, pulls the base of TR613 negative through D610, when the bistable will be reset. TR618 and TR619 (TR421 and TR422) generate the "B" bright-up current, and the "B" gate output signal respectively. TR611 will reset the "B" bistable at the end of the "A" sweep if this occurs before the "B" ramp has reached its normal amplitude.

The "B" gate output transistor, TR422, also provides the "B ends A" pulse which is used in the mixed mode, and is taken via C632 to a gate, D630/D632/R659/R739, and from there to the A timebase (see Mixed mode). In the "A intensified by B" and the "B" modes the "B" ramp generator operates in a manner similar to the "A" ramp generator current through R719, turns on gate, D620/D618, and effectively connects the emitter of TR631 (TR429) to ground.

The source-follower, TR622 (TR426), is not half of a matched pair of F.E.T's in this case, but has a simple current source, TR623 (TR425), as a very high impedance load. The emitter-followers, TR627 and TR629 (TR427, TR428), are connected directly to TR631 (TR429). TR628 (TR431) provides the flyback current. The "B" ramp is taken from the emitter of TR629 via the gate, D625 and D626.

In normal operation the "B" ramp will be reset at the end of a sweep so that in the quiescent state, TR631 is operating as an amplifier transistor, part of the negative feedback loop, TR631, TR628, TR622, TR627 and TR629. In the mixed mode, the gate (D620 and D621) connecting the emitter of TR631 to ground, is turned off, and the gate, D619 and D624, is closed to connect its emitter to the "A" ramp output voltage. In the reset state of the "B" ramp generator, as the "A" ramp voltage goes negative, the feedback loop will make the "B" ramp follow. When the "B" sweep starts, the feedback loop is broken as TR628 is turned off, and the "B" ramp runs normally but starting from the "A" ramp level.

4.18 THE BRIGHT-UP AMPLIFIER

The Bright-up amplifier which controls the Z modulation of the C.R.T. consists of an inverting amplifier, TR902, TR904 and TR903, with shunt feedback applied through R919; the base of TR902 being a virtual earth point. The inputs include current pulses from the "A" and "B" timebase bistables, (TR421, TR618 respectively), chop blanking current pulses from TR218, and external Z modulation current waveforms (from emitter-follower, TR901, and R913), a d.c. current derived from the INTENSITY control, R60, through R912, and a bias current through R909, obtained from the timebase DISPLAY switch circuit and the CONTRAST control. The instantaneous sum of these input currents is balanced by the feedback current from the output through R919, so that the output voltage waveform follows the sum of the input currents.

The operating levels in the various display modes are tabulated overleaf.

The mixed mode follows the "A intensified by B" bright-up condition. The Intensity control current and the Ext. Z modulation current are added through D904, the maximum intensity condition being when the current in D904 is zero, and the blanked condition being when the current in D904 is +2mA.

During the chop blanking period, a further +2mA current pulse is added which makes total applied input current $\geqslant$+2mA, and blanks the trace for all settings of the brilliance control.

The maximum output from the amplifier is approximately 25 volts, corresponding to this 2mA change in input current. The diode, D905, ensures that when the amplifier is overloaded by a negative input, the "A" and "B" bright-up inputs do not move far from their normal working voltage.

Diodes, D908 and D909, ensure that TR904 does not bottom. TR903 provides essentially a high impedance constant current load for TR904 but C904 causes it to act as a complementary amplifier with TR904, to provide a low output impedance at high frequencies to drive the mainly capacitive load.

The output of the amplifier is connected via C911 directly to the grid of the C.R.T, and through R923 to the low voltage side of the floating grid supply. The dc voltage with respect to ground applied to the grid is then determined by the potentiometer, R928, (to allow for variations in grid cutoff between C.R.T's), resistor chain, R930/933, across the grid supply and the voltage on the output of the amplifier.

Display Mode	Condition	Input Current				Total Current in D204	Intensity Control Range
		Bright-up		Bias			
		'A'	'B'	Contrast MAX.	Contrast MIN.		
EXT X		+2mA	+2mA	−4mA	−4mA	0	Full Inten to Blanked
'A'	Waiting	+2	+2	−2	−2	+2	Blanked
	running	0	+2	−2	−2	0	Full Inten to Blanked
'A' intens by 'B'	'A'&'B' Waiting	+2	+2	0	−2	+4/+2	Blanked
	'A' running	0	+2	0	−2	+2/0	From Inten set by CONTRAST to Blanked
	'B' running	0	0	0	−2	0/0*	Full Inten to Blanked
'B'	'A'&'B' Waiting	+2	+2	0	0	+4	Blanked
	'A' running	0	+2	0	0	+2	Blanked
	'B' running	0	0	0	0	0	Full Inten to Blanked

*D904 prevents reversal to −2mA.

The time constant, C911/R929, is much longer than the time constant, C912/R923, so that a voltage step of say +25V at the output of the amplifier is coupled to the grid and held by C911 and R929, while C912 rapidly charges through R923, causing the floating grid supply to rise by +25V. This causes the voltage across R928 to be reduced to zero before C911 can discharge significantly, preventing any further change in grid potential. Any voltage change on the output of the amplifier is faithfully reproduced on the grid by this means. The neons, N901 and N902, protect the C.R.T. from excessive grid-to-cathode voltage on switch-on or switch-off.

EXT. Z MODULATION

R903, R905, R906 and R907 form an attenuator and dc shift circuit for Ext. Z modulation signals. D907 and D901 are protection diodes. R913 defines an input current to the bright-up amplifier from emitter-follower, TR901. The voltage gain from the Z mod input socket to the output of the bright-up amplifier is approximately unity and high frequency signals are connected via C901, R904 and C906 to the C.R.T. cathode, so that the bandwidth of the Ext.Z modulation is not limited by the bandwidth of the bright-up amplifier.

4.19 X GATE AND X OUTPUT STAGE

The input of the X output amplifier can be connected to either "A" or "B" ramp outputs, or the output of the External X amplifier as determined by the Display switch, S50, and the "A" timebase range switch, S43. This switching is performed by diode gates, D432/D433 and D625/D626 for the "A" and "B" ramps respectively and by D603 for the External X amplifier.

When External X is selected on the "A" timebase range switch, −15V is applied via R549 and R742 to the "A" and "B" gates respectively, cutting off both, irrespective of the position of S50. Simultaneously +15V is applied to the External X amplifier supply rail, bringing its output (emitter TR604) to approximately +2V. With the "A" and "B" gates off, current flows from R651 through D603 to the emitter of TR604, thus connecting this point to the input of the X amplifier, PLB12.

With the "A" timebase range switch in any position other than Ext. X, S50 determines which ramp gate functions by applying either a negative voltage (off) or +15V (on) to R549 or R742. The Ext. X amplifier and gate are disabled by the removal of +15V from its supply line. In the positions "A" and "A intensified by B" the "A" gate is turned on and "B" gate turned off. In the "B" position and "A and B Mixed" position, the "A" gate is turned off and "B" gate turned on.

The ramp selected by S50 is passed to the base of TR953, one half of a long-tailed amplifier, TR953/TR954, for which TR955 is a constant current source to provide good common mode rejection. The emitter resistors of this stage can be switched to give a x10 increase in gain. The shift voltage derived from the shift control, R602 and R603, is passed by emitter follower, TR952, to the other input

of the long-tailed pair. The differential output of this stage is then the sum of the ramp and shift signals. This signal is connected directly to the bases of TR958 and TR959, a long-tailed pair which is the lower part of a balanced cascode amplifier whose upper stage is TR956 and TR957. The gain of this stage is determined by the emitter feedback resistor, R982, and the load resistors, R976, R979. R983 and C953 provide high frequency compensation. The diodes, D953, D952, D955 and D954 prevent TR956 and TR957 from saturating. The output from the collectors of TR956 and TR957 is taken directly to the X plates of the C.R.T.

4.20 EXTERNAL X AMPLIFIER

The circuit for the external X amplifier is included on the 'B' timebase circuit Fig. 6. The external input signal is applied to the base of the amplifier transistor, TR603, through the capacitor/resistor network, C606/R619. The trimmer, C645, is used to set the H.F. response. The diode, D600, protects the base-emitter junction of the transistor against excessive reverse voltage. Resistors, R618 and R620, together with R619 set the quiescent base voltage of the input transistor. Capacitor, C607, provides some HF peaking. The collector voltage swing is passed via emitter-follower, TR604, through diode, D603, (if enabled) to the X amplifier. Only when External X is selected, is the +15 volt line connected via the 'A' timebase range switch to enable the amplifier.

4.21 RAMP AND GATE OUTPUTS

THE 'A' RAMP OUTPUT

Mounted on the interconnect printed circuit board is the inverting buffer amplifier connected to the 'A' ramp via PLA1 of SKA. The 'A' ramp, running from near zero to approximately −4V, is connected directly to the base of TR951. This transistor is biased on by emitter resistors, R953 and R952. A positive-going ramp (0V to +10V) is generated across the collector load, R951, and is taken, via R954, to the output socket, (SKJ).

THE 'A' GATE OUTPUT

This signal is taken from the collector of TR422 in the 'A' timebase. The transistor is driven from the timebase bistable and gives a positive output pulse while the 'A' ramp is running. The pulse is taken through R503 and SKA to the rear panel, SKK.

THE 'B' GATE OUTPUT

This output is taken from the collector of TR619 in the 'B' timebase. The transistor is driven from the timebase bistable and gives a positive output pulse while the 'B' ramp is running. The pulse is taken through R684 and PLB3 of SKB to the rear panel, SKL.

4.22 CALIBRATOR

The circuit diagram for the calibrator is included on the 'B' timebase circuit, Fig. 6.

The components forming this circuit are mounted on the 'B' timebase P.C. assy. The circuit consists of an emitter-coupled oscillator, TR624 and TR625, with C634 as the timing capacitor.

The collector current through TR625 is used to turn TR626 on and off to give a square wave output across R732. This is set to be 1 Volt peak to peak by R730.

The values of the resistors in the dividing chain are selected such that the output resistance is 200Ω, giving a 5mA calibrator current if the output is shorted.

4.23 THE POWER SUPPLIES

The 1040A basically operates from positive and negative 15V lines and a +150V line, each stabilised and independently protected against overload. The E.H.T. lines are all obtained from a high frequency oscillator with overload protection but with direct stabilisation only on the −1.5kV CRT cathode supply. This oscillator is supplied from the +20V unstabilised line used for the +15V line.

All supplies are obtained from transformer, T83, via the range selector switch, S81, the supply fuse, FS83, and supply on/off switch, S80.

One secondary from T83 is the 6.3V supply to the CRT heater and another the low voltage (approx. .25 Volt) for the line trigger signal. This latter voltage passes via SKB − PLB19 and PLB20 to the trigger selector switches. The three remaining secondaries are rectified and smoothed as follows.

4.23.1 +15V, −15V and +150V LINES

One secondary from T83 feeds the bridge rectifier, MR83, and develops approximately 20V across capacitor, C85. This is used to obtain a stable, overload protected, −15 Volt line using an integrated circuit regulator, IC801, which contains a reference, comparator input amplifier and output current amplifier. In addition it includes the overload protection circuitry to operate from the voltage developed across the current sensing resistor, R836. The output from this IC regulator drives the external series regulator, TR838.

The output of the line is set to be −15V by the preset potentiometer, R838. Components, R855 and C831, reduce the noise present on the internal reference and C832 gives feedback compensation to prevent oscillation.

A similar secondary from T83 is rectified by MR82 and develops approximately +20V across C84. Protected by FS832 this +20V supply feeds the EHT oscillator. The voltage across C84 is also used to obtain the stablisied +15 volt line.

TR833, TR834, TR835 and TR837 form the +15V stabiliser circuit, which is referenced to the −15V line. If the +15V line is not at the correct potential, the junction of the two equal resistors, R847 and R848, will not be at 0V. The resultant differential voltage between the bases of TR833 and TR834 will modify the collector current of TR833 to drive through TR835 to the series regulator element, TR837, and so correct the line potential.

Excessive current drawn from the +15V line will develop a potential across R835 causing D833 to conduct in turn limiting the base current to TR835 and so also that in TR837.

Protection diodes, D835 and D836, are normally reverse biased and only conduct in the accidental condition of a short circuit between the +15V and −15V lines.

Diode, D834, protects the base-emitter junctions of TR833 and TR834 against excessive reverse voltages. Capacitors, C836 and C833, give h.f. roll-off to prevent oscillation; C835 reduces output ripple.

The secondary from T83 is rectified by MR81 and develops approximately 180V across C83.

R84 and C86 reduce the output line ripple. The +150 Volt line is referenced from the −15 Volt line by resistors, R842 and R843. Any error potential at the junction of these resistors drives the error amplifier, TR831, which in turn controls the series transistor, TR839. Transistor, TR832, protects TR839 from over voltage at switch on, or in the event of failure of the −15V line. If the junction of the potential divider, R840 and R841, goes too far negative, TR832 conducts allowing TR839 to conduct.

Short circuit protection on the 150V line is by means of the fuse, FS831.

4.23.2 E.H.T. SUPPLIES

The EHT supply circuitry as shown in Fig.10 is contained within the EHT box assembly. It comprises an oscillator driving a transformer with three secondaries, each rectified to provide the three lines of approximately −1580 volts, −1500 volts and +9kV.

The oscillator is formed by the center tapped primary winding, of the transformer in the collectors of transistors, TR814 and TR815, with feedback windings taken to the bases via protection diodes, D813 and D814. The center tap of the primary is taken through the choke, L801, to the supply and that of the secondary being returned to the supply through R818.

The waveform at the collectors is approximately alternate half waves of 55 volts amplitude at 30kHz.

The independent grid supply from one high voltage secondary winding is rectified and smoothed by D805 and C807. The cathode supply from a further secondary is rectified and smoothed by D804 and C804, and is stabilised by a feedback circuit which controls the supply switched to the primary of the transformer.

The current through R803, (the focus control potentiometer) and R821 is compared with the reference current taken from the +15 volt line through the 'set EHT' preset (R854) potentiometer on the power supply P.C. assembly and R816.

The difference signal is amplified by TR811 which controls TR812 and in turn the series regulator, TR813, which controls the supply line for the oscillator at approximately 14 volts.

Overload protection is provided when the voltage across R814 causes D811 to conduct, thereby reducing the drive into TR812. The output from TR813 is limited to approximately 600mA and if this current is maintained, the fuse FS832 on the power supply P.C. assembly will blow.

The third high voltage secondary winding is connected in series with the cathode winding to give approximately 3kV p-p a.c. input into the tripler circuit, D801, D802 and D803, with capacitors, C801, C802 and C803. The ripple present on this output is removed by the additional filter circuit, R801 and C806, and the resultant +9kV used as the P.D.A. potential for the CRT.

4.24 CATHODE RAY TUBE AND ITS INPUTS

The 1040A employs a conventional mesh PDA tube with a high efficiency aluminised screen.

The interconnection diagram fig. 11 shows the necessary connections to the various electrodes.

THE GUN

An independent winding on the mains transformer drives the heater for the cathode. The beam current and hence the spot intensity is controlled by the differential potential between the grid and cathode. The −1.5kV cathode potential is the direct stabilised output from the EHT oscillator. The grid potential is the sum of the floating grid supply from the EHT oscillator and the output potential of the bright-up amplifier to which the grid supply is referred.

The CRT beam is brought to a clear, well focussed spot by varying the potentials applied to the focus and astigmatism electrodes. These signals are derived from R82 (focus) and R81 (astigmatism) mounted on the front panel, the latter being a screwdriver adjustment. The focus electrode is normally variable over the range −1100V to −1350V and the astigmatism from +150V to 0V.

THE DEFLECTION SYSTEM

The Y plates are connected to the output of the Y amplifier and the differential signal applied, deflects the beam in the vertical direction. The mean plate potential is normally +55V and the sensitivity is approx. 4.5V/cm.

Similarly, the X plates are connected to the X output amplifier and the differential signal deflects the beam in the horizontal direction. The mean X plate potential is normally +60V and the sensitivity is approx. 16V/cm.

The deflection plate shield, S1, screens the deflection plates from the other electrodes and is held at a potential of +50V obtained from the junction of R936 and R937 on the bright-up p.c. board.

The interplate shield, S2, screens the X plates from the Y plates and is held at a potential 15V more negative than the X mean plate potential, derived from the wiper of R381 on the 'Y' output p.c. board.

Shield, S3, the geometry electrode, is set for optimum linear deflection in both the X and Y axes. Its potential can be varied over the range +150V to −15V and is derived from the wiper of R851 on the power supply.

Having passed through the deflection plate system the beam accelerates to the screen which is held at +9kV by an output from the EHT oscillator, striking the phosphor at high velocity to produce the necessary bright trace.

THE TRACE ROTATION COIL

A coil, L83, fitted round the neck of crt, inside the magnetic shield is used to align the trace with the horizontal graticule lines.

The current for this coil is taken from the preset potentiometer, R850, through R849, on the power supply board. The direction of rotation can be reversed by reversing the connection of the leads to the coil.

4.25 GRATICULE ILLUMINATION

The external graticule is illuminated by two lamps.

The supply for these lamps is derived from the emitter-follower, TR836, on the power supply board; being set by the graticule illumination potentiometer, R80, on the front panel.

Both the emitter-follower and the control potentiometer are supplied from the full-wave rectified signal taken from the transformer at the junction of diodes, D83 and D84.

5.1 GENERAL

The instrument is electrically protected by three fuses as follows:–

1. 1A 'Slo-blo' Size 0 (FS80) in the supply input and mounted on the rear panel.
2. 250mA Size 00 (FS831) in the +150V supply line and mounted on the Power Supply board.
3. 500mA Size 00 (FS832) in the +20V line supplying the E.H.T. Oscillator also mounted on the Power Supply board.

Access to the two latter fuses is by removal of the bottom cover.

The following sections give information allowing access to and removal of the various printed circuit boards and assemblies as may be found necessary, during fault finding procedures.

If, during fault finding a component needs replacing, it should be cut from the printed circuit board as close as possible to the component, leaving the wires connected to the copper track and protruding through to the component side of the board. The new component should then be soldered into position by attaching it to these protruding wires. This protects the copper track from damage.

If a fault on a printed circuit board cannot be cleared, it is recommended that the instrument is returned to the manufacturer for repair. When faults have been cleared it is recommended that the test procedure is implemented to ensure that the instrument conforms to the specification.

5.2 ACCESS

Figures 14, 15, 16 and 17 illustrate various views of the instrument showing access to the majority of preset components when the top and bottom covers have been removed. Each cover is retained in position by four latch fasteners. Each fastener is released by turning it one quarter of a turn clockwise or counter-clockwise.

The construction of the instrument has been arranged so that individual boards and assemblies can be checked and components changed without actually removing the assemblies from the main frame or disconnection of cable forms. In the case of the Time Base unit this has been achieved by making it a plug-in assembly which can be removed and operated on an extension lead. This assembly is then still fully functional and access is provided to both sides of both printed circuit boards.

The following description details the method for removing the individual assemblies:–

5.2.1 ATTENUATOR AND PRE-AMPLIFIER ASSEMBLY

1. Each assembly is fitted with its own screening cover and it is only necessary to remove the cover from the unit requiring attention. The procedure is identical for both attenuator assemblies.
2. Having removed the screen, take out the shift control spindle by loosening the grub screws on the universal coupling, also remove the coupling.
3. Unsolder the three supply leads and four signal leads from the rear of the horizontal printed circuit board.
4. Remove the knob from the VOLTS/cm selector switch and its fixing nut, the lever switch knob and the coaxial socket. Later models do not require the removal of this socket but have a stud behind the front panel mounted between the BNC socket and the lever switch.
5. The unit can now be removed by lifting first from the rear to clear the shift control support bracket and pulling towards the rear of the instrument.
6. Care should be taken when removing the left hand unit not to disturb the graticule illumination lamp, also ensure that this lamp is correctly positioned when the unit is replaced.
7. For fault finding, the unit may be operated out of the frame by extending the supply and signal leads. Providing that the signal leads are kept reasonably short, the complete channel may be checked at frequencies approaching the full bandwidth.

5.2.2 BEAM SWITCH & DELAY LINE EQUALIZER BOARD

1. Disconnect the signal leads from the rear of the board and remove the seven fixing screws.
2. The board may now be brought carefully to the upright position without unsoldering any further connections. This operation then gives access to both sides of the board.
3. If it is required to operate the board in this position, it is recommended that the output should be reconnected via extended leads.
4. Raising this board also gives access to the POSITION control potentiometers, the x5 GAIN pull switches and the Y2 INVERT switch.

5.2.3 DELAY LINE

1. The Delay Line is mounted in a tray above the shield, by means of four screws, two through the top of the front extrusion and two on the rear tube support assembly.

5.2.4 OUTPUT BOARD

1. Remove the two Y Plate leads and the S2 connection from the tube side pins.
2. Remove the board fixing screws and also the screws attaching the output transistor heat sink to the tube support assembly.
3. The board, together with the output transistors, may now be swung out of the frame on the connecting leads giving access to both sides of the board.
4. The output transistors can be changed without removing the board by taking out the three fixing screws and lifting the plastic clamp.

5.2.5 TIME BASE UNIT

1. Remove the fixing screws from the Time Base section of the front panel and also slacken the two fixing screws attaching the rear of the unit to the cross bar (see fig.2).
2. Carefully draw Time Base Unit through the front of the instrument, taking care not to catch any components on the front extrusion.
3. Check that both polarising keys are still correctly positioned in the multiway connectors.
4. Both Time Base Boards are now accessible and the unit may be operated on Timebase Extender Cable 88100040A.

5.2.6 BRIGHT-UP AMPLIFIER BOARD

1. Remove the plastic protective cover and unsolder the two leads marked:– BU BIAS and A + B.
2. Removal of the four hexagon threaded spacers allows this board to be lifted into the vertical position from the edge closest to the centre of the instrument, thus giving access to both sides.

5.2.7 POWER SUPPLY ASSEMBLY

The low voltage power supply unit is on a removable sub-chassis mounted in the rear of the instrument.

1. Remove the screws securing the moulded rear cover, and remove the cover.
2. Remove remaining screws holding the unit on to the rear extrusion and the screw supporting the Bright-Up Amplifier support bar.
3. Remove the four screws, XX and YY, in the rear cross bar (See fig. 2).
4. The unit may now be removed from the frame as shown in fig. 1, to the distance provided by the loop in the cable form.
5. Access is now provided to the power transformer and VOLTAGE SELECTOR switch, smoothing capacitors and series regulating transistors.

5.2.8 POWER SUPPLY PRINTED CIRCUIT BOARD

1. Remove the four fixing screws.
2. The board will now lift into the vertical position on its cable form giving access to both sides.
   i) **X Amplifier and Interconnect Board**
   Access to this board may be obtained by removing a number of units as previously described, namely:– Time Base Unit, Bright-Up Amplifier and Power Supply Assembly.

5.2.9 E.H.T. UNIT

1. Remove the two screws at the top of the box, which pass through the box and into the center bar of the instrument.
2. Lift the box out of the instrument on its cable form.
3. Remove the six screws which hold the lid and remove. Insert one of the long fixing screws through its original hole in the rear of the box and screw into the threaded insert provided in the centre bar of the instrument. This secures the unit for servicing purposes.
4. The oscillator printed circuit board and transformer are now accessible. The printed circuit board may be slid out on its runners to provide access to both sides.

5.2.10 CATHODE RAY TUBE

1. Access to the base of the tube is possible by removing the moulded cover which is attached to the rear of the instrument.
2. The tube may be removed by withdrawing from the front after taking off the escutcheon and graticule assembly.
3. Before attempting to extract the tube, remove the side pin connectors and the base. It will also be necessary to unsolder the twist coil leads from the interconnection printed circuit board (pins TWIST & 0V). The twist coil is attached to the tube and therefore its leads should be fed through the hole in the shield as the tube is pulled forward.
4. Care should be taken when removing the tube not to bend the side pins as this may crack the glass around the seal.

5.3 FAULT FINDING TABLES

Faults may be localised by reference to the Fault Localisation information presented in fig. 18 and the Circuit Voltages listed in paragraph 5.4.

These measurements should be used as a general guide of voltage obtainable at certain locations within the instrument and can be used as an aid to servicing.

The power supply input voltage should be approximately at the mid range of the Supply Voltage setting. The power supply voltages in the tables are those appearing under these conditions. Other voltages assume that the Y inputs are grounded and the amplifiers are set to 5mV/cm sensitivity. The Time Base is set to FREE RUN, Y1 Mode with Y1 trace brought to the centre of the screen.

5.4 OPERATING POTENTIALS

(a) INPUT ATTENUATOR AND PRE-AMPLIFIER

Location		Voltage
TR101 and TR102	Drains	7.2V
TR101 and TR102	Sources	0 to +2V
TR103 and TR104	Collectors	7.8V
TR103 and TR104	Emitters	+0.7 to +2.7V
TR121 and TR122	Collectors	+4V
TR120	Collector	–5.5V
TR123 and TR124	Collectors	+6.6V
TR125 and TR126	Bases	+8.6V
"Trig" output		+7.9V
"Sig" output		+7.6V

(b) BEAM SWITCH AND DELAY LINE EQUALIZATION

Location		Voltage
TR201,202,207 and 208	Emitters	+8.6V
TR202 and TR208	Collectors	Nominally 0V
TR207	Collector	+0.8V
TR203,204,205 and 206	Collectors	+5.4V
TR209	Collector	+2.5V
TR209	Base	+0.8V
Y2 O/P		Nominally 0V
TR210 and TR211	Collectors	+6.3V
TR214	Collector	+7.4V
Pin 31 and 33		+5V
TR215	Collector (Y1 Selected)	+2V
TR215	Collector (Y2 Selected)	+7V
TR217	Collector	+13.7V
TR218	Collector	+2.8V
TR300 and TR301	Emitters	+4.1V
TR300 and TR301	Collectors	–1.4V
TR302 and TR303	Collectors	–2.3V
TR304 and TR305	Collectors	+3.8V
Pins 43 and 44		+7.5V

(c) Y OUTPUT AMPLIFIER

Location		Voltage
TR351 and TR352	Collectors	+11.5V
TR355	Collector	+5V
TR353 and TR354	Collectors	+55V
Pin S2		Approx 40V

(d) X OUTPUT AMPLIFIER AND INTERCONNECT

Location		Voltage
TR953 and TR954	Collectors	−8.0V
TR968 and TR969	Collectors	−5.7V
TR956 and TR957	Collectors	+60V

(e) BRIGHT-UP AMPLIFIER

Location		Voltage
TR901	Emitter	+1.2V
TR904	Collector (Ext X Mode, Max Inten.)	+25V
Vg. Hi		−1580V
Vk		−1500V

(f) E.H.T. SUPPLY

Location		Voltage
TR813	Collector	+20V
TR813	Emitter	+15V
TR811	Collector	+17.3V
PDA	Connector	+9kV

(g) LOW VOLTAGE POWER SUPPLY

Location		Voltage
TR837	Collector	+20V
TR835	Collector	+15.5V
TR833	Collector	−0.65V
TR839	Emitter	−18V
TR836	Collector	+15V
TR838	Collector	+8.5V

(h) TIMEBASES

Operating potentials and waveforms within the timebase unit are shown in figs. 12 and 13.

SINGLE SWEEP I.C.

	I.C. Pin No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Lever position	Arm	0	2.5V	3.6	4.4	4.8	0	0	4.4	0	0	0	2.5	0	5
	Single Sweep(Armed)	0	2.5V	3.6	0	0	4.4	0	0	4.4	4.8	0	2.5	0	5
	Single Sweep (Fined)	3.8V	2.6	0	0	0	4.4	0	0	4.4	4.8	3.8	2.5	0	5

5.5 CALIBRATION PROCEDURE

5.5.1 TEST EQUIPMENT

1. Variable autotransformer. Output voltage 95 to 260V at 1A with ac rms voltmeter. (Variac).
2. Multimeter. 0-2.5kV with at least 20,000 ohms/volt sensitivity. Accuracy within 2%
3. Voltage Calibrator. 1kHz squarewave generator with amplitude 5mV to 100V. Accuracy within 1%.
4. Time Mark Generator. Marker generator of 0.5μs to 1 sec. Accuracy within 1%.
5. Squarewave Generator. 1MHz flat top square wave generator with adjustable amplitude 0.1V to 1V into 50 ohms having a rise time of less than 2ns.
6. R.F. Sinewave generator. 500kHz to 50MHz with 50kHz reference frequency. Output amplitude 25mV to 5V p-p into 50 ohms. Amplitude accuracy at 50kHz and 500kHz to 50MHz within 3%.
7. LF SineWave Generator.
8. Capacitance Standardizer. 1MΩ/28pF, BNC 50Ω termination, BNC-BNC connector lead, Timebase Extender Cable 88100040A.
9. E.H.T. Meter 0-10kV.

NOTE Calibration should be carried out at normal ambient temperature and should not be commenced until the instrument has been operating for at least 15 mins.

5.5.2 SET SUPPLY RAIL VOLTAGE

1. Set the INTEN control to minimum.
2. Set the SUPPLY VOLTAGE switch on the rear panel to suit the supply. Apply the supply voltage via the Variac set to mid range of the Supply Voltage setting.
3. Check that the GRATICULE control varies the graticule intensity and that the neon, N80, is energised.
4. Connect the multirange meter between chassis and pin '−15V' on the Power Supply printed circuit board. Adjust the voltage to −15V ±2% by means of R838.
5. Check that the voltage to chassis on the following pins on the Power Supply printed circuit board, are within the following limits,

   '+15V' +15 ±4%
   +150V +150V ±4%
6. Set the multirange meter to read 2500V and meter between chassis and pin 'VK' on Bright-Up Amplifier printed circuit board. Adjust R854 on Power Supply printed circuit board for a reading of −1500V.
7. Check that e.h.t. supply at tube cavity cap connector is +9kV ±0.5kV.

5.5.3 SET TUBE CUT-OFF AND VISIBLE DELAY

Due to small changes in the c.r.t. control grid characteristics during warming up, the first part of the adjustment should be made as soon as a trace appears after switch-on.

1. Advance BRIGHTNESS Control to the '9 o'clock' position. Adjust R928 on Bright-Up Amplifier printed circuit board so that the trace is just not visible.
2. Set the TIME BASE controls to give a sweep rate of 20ns/cm. Inject the 1MHz fast rise pulse and adjust trigger so that the leading edge is visible.
3. Adjust trimmer, C905, on Bright-Up Amplifier printed circuit board for maximum visible delay with no brightened up spots appearing at the start of the trace.

5.5.4 Z MODULATION

1. Apply a 1KHz square wave of 5V amplitude to the Z MOD socket on the rear panel and to Y1 INPUT socket with Y1 VOLTS/cm switch set to 2V.
2. Obtain a stable trace and check that the modulation is just visible.
3. Increase input to 20V p-p, check that the trace can be fully blanked and that positive signals cut off and negative signals brighten up the trace.

5.5.5 X AMPLIFIER ADJUSTMENTS

These adjustments should be carried out with the TB unit on the Timebase Extender Cable to give access to controls.

1. Set "A" TIME/cm to EXT X and VARI TIME/cm control to CAL.
2. Inject a 10V p-p 1kHz square wave into the EXT X socket.
3. Adjust R972 on X Amplifier and Interconnect printed circuit board, to give 10cm of X deflection.
4. Pull 'A' Time Base x10 control.
5. Inject a 1V p-p 1kHz square wave into the EXT X socket.
6. Adjust R969 on X Amplifier and Interconnect printed circuit board to give 10cm of X deflection.
7. Inject an 8V p-p 10kHz square wave into the EXT X socket. Pull X Amp x10 'In'. Adjust C645 (Time Base 'B' printed circuit board) to remove any 'tail' which extends beyond the bright spots at the extremes of the deflection.

5.5.6 TIME BASE ACCURACY ADJUSTMENT

These adjustments should be carried out with the Time Base operating on the Timebase Extender Cable to give access to the appropriate controls.

A Time Base:–

1. Set "A" TIME/cm to 1mS/cm, VARIABLE TIME/cm Control fully clockwise.
2. Inject 1kHz marker pulses into Y1 channel and trigger for a stable trace.
3. Adjust R510 on 'A' Time Base printed circuit board for 1 marker pulse per cm.
4. Set Time Base Range Switch to 0.5μs/cm, VARIABLE TIME/cm Control fully clockwise.
5. Inject 2MHz marker pulses into Y1 channel and trigger for a stable trace.
6. Adjust C435 on 'A' Time Base printed circuit board for 1 marker pulse per cm.
7. Check that 'A' TIME/cm VARIABLE gives greater than 3:1 reduction in speed.

B Time Base:–

The procedure should be repeated for the 'B' Time Base, adjusting R708 at 1kHz and C631 at 2MHz. These controls are situated on the 'B' Time Base printed circuit board.

5.5.7 TRIGGER LEVEL SLOPE BALANCE ADJUSTMENT

Adjustment to be carried out with Time Base on Timebase Extender Cable 88100040A.

A Time Base

1. Inject a 1KHz sine wave into Y1 and set TRIGGER LEVEL control to mid-position, TRIGGER COUPLING in AC position.
2. Adjust R453 ("Slope Bal") so that there is no significant movement of the trigger point when the TRIGGER SELECT Switch is moved from "+ve to –ve".
3. Move TRIGGER COUPLING to DC position and adjust R213 to obtain the same trigger point. Repeat using Y2 channel and R223.

B Time Base

The above procedure should be repeated for the 'B' Time Base adjusting R643 to give the desired effect.

5.5.8 INTERNAL 1v CAL. ADJUSTMENT

Adjustment to be carried out with Time Base on Timebase Extender Cable 88100040A.

1. Inject 1V p-p 1kHz square wave into Y1 channel from external calibrator. Set Y1 VOLTS/cm to 0.1V and adjust VARIABLE GAIN Control to give exactly 8cm deflection.
2. Substitute internal cal. waveform for signal from external calibrator and adjust R730 to give exactly 8cm deflection.

5.5.9 CHANNEL 1 & 2 FINE GAIN CONTROL BALANCE

1. Set Y1 VOLTS/cm switch to 5mV, INPUT COUPLING Switch to GND, Mode switch to Y1, Time Base to Free Run.
2. Set trace on centre line by means of Y1 shift control. Adjust front panel BAL control to give no trace movement when the Y1 FINE GAIN Control is operated.
3. Repeat procedure for Channel 2.

5.5.10 CHANNEL 1 & 2 STEP ATTENUATOR BALANCE

1. Set Y1 VOLTS/cm switch to 20mV, INPUT COUPLING Switch to GND, Mode switch to Y1, Time Base to Free Run.
2. Set trace on center line by means of Y1 POSITION control. Adjust R123 (Y1) to give no trace movement when the VOLT/cm switch is moved to 5mV/cm.
3. Repeat procedure for Channel 2, adjusting R123(Y2).

5.5.11 ADJUST TRACE ALIGNMENT

Set Time Base to 1ms/cm and TRIGGER SELECT to FREE RUN.

Adjust R850 to bring the trace parallel to the horizontal centre line. If there is insufficient range, reverse pink lead connections to pins marked "Twist" and '0V' on X Amplifier and Interconnection printed circuit board.

5.5.12 GEOMETRY

Apply to Y1 INPUT a 1kHz sinewave to give an amplitude of 8cm, adjust ASTIG and FOCUS controls for a sharp display and set Time Base to display approximately 10 cycles. Adjust R851 for a compromise between horizontal and vertical deflection to eliminate pincushion and barrel distortion. Reset ASTIG and FOCUS controls if necessary.

5.5.13 BACKGROUND ILLUMINATION

Adjust R381 to set voltage on S2 (Y O/P Board) to 15 volts negative with respect to the X mean plate potential.

5.5.14 DELAY LINE MATCHING

1. Set Y1 VOLTS/cm switch to 20mV, inject 1MHz squarewave to give 6 cm deflection, adjust trigger to give stable trace.

2. Inspect top of waveform for any step occurring approximately 200μs after the start of the pulse.
3. If any step is present replace A.O.T. resistor, R265, with a small 220Ω carbon potentiometer on short leads, adjust for no step, measure required value and substitute fixed resistors of nearest preferred value.

5.5.15 'ADD MODE' AMPLIFIER BALANCE

1. Set FUNCTION SWITCH to CHOP and bring both traces to the centre horizontal line, by means of Y1 and Y2 POSITION controls
2. Set the MODE SWITCH to ADD and note the direction and amount of movement of the trace. Return to CHOP Mode.
3. Add 100kΩ potentiometer across a.o.t. position, R294 or R295, to give a direction of movement the same as that given when moving from CHOP to ADD.
4. Adjust potentiometer to bring both traces to position found in '2'.
5. Re-centre traces, switch to ADD, movement should now be less than 0.5 cm.
6. Replace potentiometer with fixed resistor of the nearest preferred value.

5.5.16 CHANNEL 1 and 2 GAIN ADJUSTMENT

1. Set Y1 VOLTS/cm switch to 20mV, INPUT COUPLING Switch to DC, FINE GAIN CONTROL to Cal.
2. Inject a 1kHz squarewave having an amplitude of 120mV into Y1, adjust R227 to a deflection of 6 cms.
3. Switch to 10mV range, inject 60mV and adjust R138 (Y1) to give 6 cm deflection.
4. Switch to 5mV range, inject 30 mV and adjust R136 (Y1) to give 6 cm deflection.
5. While still on 5mV range, inject 6mV, pull for X5 gain and adjust R229 to give 6 cm deflection.
6. Switch to all other ranges and inject the appropriate signal to give 6 cm deflection. Check that all ranges are accurate to within ±3%.
7. Repeat the above procedure for Channel 2 the adjustments for the 20mV, 10mV, 5mV and 1mV ranges being respectively, R231, R138 (Y2), R136 (Y2) and R233.

5.5.17 CHANNEL 1 and ATTENUATOR COMPENSATION

1. Ensure that the attenuator covers are correctly fitted and that the link across the universal coupling on the POSITION control is continuous.
2. Set Y1 VOLTS/cm switch to 20mV, INPUT COUPLING switch to DC, Inject 200mV 1kHz squarewave via the 28pF/1MΩ standardizer. Trigger for stable trace.
3. Adjust input trimmer, C171 (Y1) for square corner.
4. Remove standardizer, switch VOLTS/cm to 0.2V, inject 1V squarewave and adjust x10 compensating trimmer, C167 (Y1), for square corner.
5. Inject 2V squarewave via standardizer and adjust x10 input trimmer, C165 (Y1), for square corner.
6. Remove standardizer, switch VOLTS/cm to 2V, inject 10V squarewave and adjust x100 compensating trimmer, C161 (Y1), for square corner.
7. Inject 20V squarewave via standardizer and adjust x100 input trimmer, C159 (Y1), for square corner.
8. Remove standardizer and check all attenuator ranges, applying the appropriate amplitude, to ensure all ranges give a square corner to the applied waveform and are accurate to within ±3%.
9. Repeat above for Channel 2 the component numbering is the same except for a suffix 'Y2'.

5.5.18 Y2 OUTPUT AMPLITUDE AND PHASE ADJUSTMENT

1. Set Y1 and Y2 INPUT VOLTS/cm switches to 0.1V. INPUT COUPLING Switches to DC. Link Y2 OUTPUT to Y1 INPUT. FUNCTION SWITCH to ALT. FINE GAIN CONTROL to CAL.
2. Inject 0.5V 1kHz squarewave into Y2 input, trigger for a stable trace.
3. Adjust R238 to give equal deflections on Y1 and Y2 (i.e. Y2 Output of 100mV/cm).
4. Remove Y2 OUTPUT link from Y1 INPUT and take to EXT X and PULL x10.
5. Apply a sine wave source to Y1 and Y2. Adjust input level to give a convenient size display which should be a 45° line at low frequencies.
6. With input frequency of 500 kHz, select capacitive value of C228 until ellipse almost closes to indicate minimum phase shift which should not exceed 3° at 500 kHz. Start recalibration by using the value provided in the instrument as adjusted on test (a.o.t.) at the factory. If desired, C228b a 10-60 pF ceramic trimmer capacitor may be installed (P/N 07-10310-0A) to provide continuously variable phase compensation to within 3° at 500 kHz. If necessary, use C228, the fixed capacitor, in parallel with the trimmer to achieve zero phase shift. C228 falls in the range of 8 pF to 47 pF.

5.5.19 Y AMPLIFIER OVERALL PULSE RESPONSE

1. Set Y1 and Y2 VOLTS/cm switch to 20mV, INPUT COUPLING Switch to DC. Ensure that the AOT R230 and R235 are initially not in circuit. FINE GAIN CONTROLS to CAL.
2. Select Y1 Mode and inject 100mV squarewave at 50kHz. Adjust R324 to give optimum flat top response.
3. Change input frequency to 500kHz. Adjust R357 and C357 for optimum flat top response.
4. Change input frequency to 1MHz. Adjust R309 and R311 to give a response having approximately 20% undershoot over the first 35-40ns.
5. Adjust C311 to improve the edge response without affecting adjustment 4.
6. Connect a small carbon 1kΩ potentiometer on short leads across a.o.t. pins R230. Adjust potentiometer and C202 to remove undershoot left in adjustment 4. Replace potentiometer with fixed resistor.
7. Inject 1MHz signal into Y2 and repeat adjustment 6 to establish correct value of R235.
8. Adjust C211 to give improvement in, without increasing, overshoot over first 15μs.

5.5.20 5mV and 10mV HF COMPENSATION

1. Set Y1 and Y2 VOLTS/cm switch to 10mV, INPUT COUPLING SWITCH to DC, FINE GAIN CONTROL to CAL.
2. Select Y1 Mode and inject 50mV squarewave at 1MHz. Adjust C123 (Y1) to give a square corner.
3. Switch to 5mV/cm, inject 25mV and adjust C122 (Y1) to give a square corner.
4. Repeat 2 and 3 for Y2 input, adjusting C123 (Y2) and C122 (Y2) respectively.

5.5.21 BANDWIDTH

1. Set Y1 and Y2 VOLTS/cm switches to 20mV, INPUT COUPLING SWITCH to DC, FINE GAIN CONTROL to CAL.

2. Select Y1 Mode and inject 50KHz from Constant Amplitude Generator to give 5cm deflection. Increase the frequency of the generator until the display amplitude falls to 3.5cms. This frequency should be greater than 40MHz.
3. Repeat '2' for 10mV and 5mV positions on Y1 and for 20, 10, and 5mV positions on Y2.
4. Repeat to 1mV/cm on both channels, the bandwidth should be greater than 10MHz.

5.5.22 CHOP WAVEFORM COMPENSATION

1. If any of the transistors or diodes associated with the beam switch are changed it may be necessary to re-adjust the capacitive balance of the circuit.
2. Set INPUT COUPLING SWITCH to GND, Couple A EXT TRIG via probe to the collector of TR218 (R283). Turn A TRIG SELECT to EXT.
3. Switch to CHOP Mode and set the two traces 0.5cm either side of the center line by means of the POSITION controls and adjust the Time Base (1μs/cm) so that individual chop transitions are visible.
4. Small amounts of capacity should be added between points 26 and 25 or 26 and 27 for Y1, and between 29 and 28 or 28 and 30 for Y2, to ensure that the chop transitions are flat and parallel to the centre line. The capacity required is usually small and is most easily achieved by using short lengths of enamelled copper wire twisted together.

TIMEBASE WAVEFORMS

These were drawn under the following conditions. The 'A' timebase was switched to 0.1ms/cm and the 'B' timebase to 10μs/cm. A 5cm 10kHz square wave was applied to the Y1 channel, and the 'A' trigger set to Y1 +ve slope. The 'B' trigger was set to "B starts after delay", or to Y1 +ve slope. The delay multiplier potentiometer was set to about 5.

PACKING INFORMATION

The 1040A is a rugged instrument built to perform in severe environments. If the unit is to be shipped or stored for long periods of time the following packing procedure is recommended:

a) Place the instrument into an oversize plastic bag and seal the bag.

b) Place the bagged instrument into a heavy duty corrugated cardboard box. The box must contain at least 2 inches of rubberized hair or equivalent cushion on all six sides of the instrument. The unit must fit snugly into the cushion and the cushion must fit into the box to prevent any movement of the instrument in transit.

c) Place the instruction manual into the box. If accessories are also to be packed put them into a separate plastic bag and pack into the cushion leaving at least two inches of cushion between the instrument and the accessories as well as an extra cushion between accessories and the box.

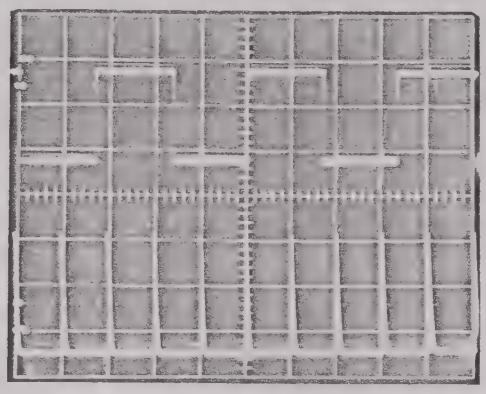
d) Seal the box fully with 2 or 3 inch wide packing tape.

e) Properly label and address outside of box with a typed label or an indelible pen.

If shipment is to the factory, notify Ballantine in advance and include detailed reasons for return inside box along with your name, firm and full mailing address. Also include your phone number and purchase order number.

Ship prepaid by United Parcel Service or Registered Air Parcel Post to:

Ballantine Laboratories, Inc.
90 Fanny Road
Post Office Box 97
Boonton, NJ USA 07005



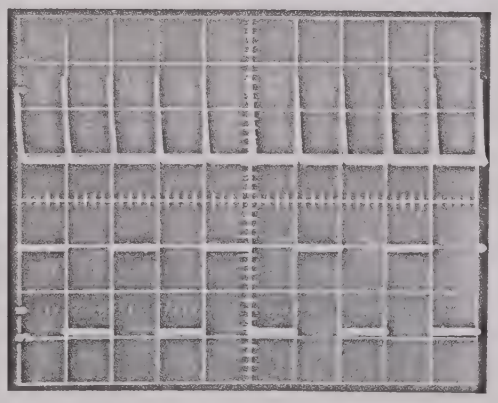
5 ms/cm
Line Frequency (60 Hz = 16.67 ms)
CAL 1 V jack on panel
(See Note Below)

Time Mark Generator
5 ms and 50 μs marks
(Note Calibration Linearity)

NOTE:
On 50 Hz power supply input period of calibration square wave is 20 ms

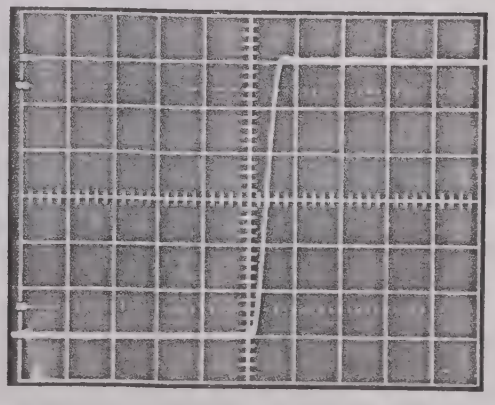
With time base set to 5 ms/cm check for 2 1/2 cycles full scale.

Figure 5-1. Horizontal Time Calibration



1 ms time markers

Amplitude Calibrating Square Wave



Fast Rise Time
50 Ω system
20 ns/cm timebase
9 ns rise time

Figure 5-2. Ballantine 6125B Calibrator Waveforms

Component List and Illustrations

Section 6

This section contains the schematics and parts lists for the 1040 Series Oscilloscopes. The replacement parts listed are available from the vendors listed or from Ballantine Labs. Your local Ballantine Field Engineering Representative may also carry a stock of parts and can assist you. If pricing quotations are required for parts and or repairs your local representative will give the most rapid service or you may contact the Ballantine Factory directly.

When ordering replacement parts always give the following information:

a) Instrument Model number
b) Serial number
c) Ballantine Part number
d) Schematic Symbol number
e) Identification of the part

Ballantine will do its best to improve the instrument and make changes in style of components and replacement parts. Replacement parts may differ in appearance from those found in your instrument but are always equal or superior in performance. Where necessary minor mechanical modifications may be required in the replacement of components.

Parts are generally available locally for most replacements. The parts list calls out the recommended vendors where applicable.

The Manufacturer Code is taken from Federal Supply Code Cataloging Handbooks H4-1, H4-2, and H4-3. Ballantine Code is 50423.

The following parts coding are used:

CVC	Capacitor, Variable, Ceramic
CCT	Capacitor, Ceramic, Tubular
CFP	Capacitor, Fixed, Plastic
CCD	Capacitor, Ceramic, Disc
CYF	Capacitor, Mylar, Foil
CMD	Capacitor, Mica, Dipped
CMM	Capacitor, Mica, Molded
CEA	Capacitor, Electrolytic, Aluminum
CET	Capacitor, Electrolytic, Tantalum
DGP	Diode, General Purpose
DZG	Diode, Zener, General Purpose
DRP	Diode, Bridge, Power
FLT	Filter
ICP	Integrated Circuit
TRQ	Transistor
RFF	Resistor, Fixed, Film
RFC	Resistor, Fixed, Composition
RVC	Resistor, Variable, Composition
RFW	Resistor, Fixed, Wirewound
SWG	Switch
LMB	Lamp
TRX	Transformer

Resistors may generally be replaced by Corning Electronics (CCW) type N-55, N-60 and C-32. Allen Bradley composition resistors type EB are also used.

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C 101	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 102	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 103	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 104	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 120	07100810A	CCD 3.3PF 500. V	90201	RMC TYPE GG
C 121	07100810A	CCD 3.3PF 500. V	90201	RMC TYPE GG
C 122	07101650A	CVC000.3-16PF TRIMMER	50423	
C 123	07101670A	CVC000.7-6PF TRIMMER	50423	
C 124	07095750A	CCD 220 PF 600 V K 10%	71590	CTL TYP DD-721
C 125	07095750A	CCD 220 PF 600 V K 10%	71590	CTL TYP DD-721
C 126	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 127	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 128	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 129	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 130	07025041A	CCT 2.7PF T	50423	999 STACKPOLE TYPE GA-SPC
C 131	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 132	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 155	07250000A	CYM 0.1 UF400.0 VK +-20%	56289	418P10404LA3 RADIAL LEADS
C 156	07200030A	CCD 47.0PF 500.0 VK +-10%	71590	CTL DD-470
C 157	07095510A	CCD 10 PF 1 KV K 10%	84171	ARC TYP CCD-100
C 159	07300000A	CVC000.8-6.8PF 400 V	80031	MEPCO 2222-802-2002 96056
C 161	07300000A	CVC000.8-6.8PF 400 V	80031	MEPCO 2222-802-2002 96056
C 163	07101620A	CMF 330.0PF 500.0 V FEEDTHRU	72982	ERIE 654-017 331K +-10%
C 165	07300000A	CVC000.8-6.8PF 400 V	80031	MEPCO 2222-802-2002 96056
C 167	07300000A	CVC000.8-6.8PF 400 V	80031	MEPCO 2222-802-2002 96056
C 168	07101580A	CMF 47.0PF 500.0 V FEEDTHRU	72982	ERIE 654-017 470K +-10%
C 171	07300000A	CVC000.8-6.8PF 400 V	80031	MEPCO 2222-802-2002 96056
C 173	07022160A	CMM 6.0NF M 20%	09023	CORNELL-DUBILIER 1D506
D 101	05100640A	DCG FD300 125 1M	07263	FCH SI
D 102	05100640A	DCG FD300 125 1M	07263	FCH SI
D 103	05100000A	DZG 1N 753A 6.2 20M .4	12954	DIC SI
D 104	05100000A	DZG 1N 753A 6.2 20M .4	12954	DIC SI
D 120	05100080A	DZG 1N9588 7.5 16M .4	12954	DIC SI DO7
D 121	05100200A	DGP 1N 752A	12954	DIC SI
D 122	05094770A	DZG MZ500-9 5.1 40M .02	04713	MOT SI DO7
L 101	46100000A	FRB FERRITE BEAD	78488	STACKPOLE 57-0180-7D MAT
R 10	09100750A	RVC 470.C 0.5 W R10	50423	
R 11	09100720A	RVC 500.C 0.5 W R21	50423	
R 101	12122400A	RFF 261.0 500 MW F+-1%	16299	CGW RN55D 2610 F
R 102	12122400A	RFF 261.0 500 MW F+-1%	16299	CGW RN55D 2610 F
R 103	12123520A	RFF 3.48K 500 MW F+-1%	16299	CGW RN55D 3481 F
R 104	12123520A	RFF 3.48K 500 MW F+-1%	16299	CGW RN55D 3481 F
R 105	12123080A	RFF 1.21K 500 MW F+-1%	16299	CGW RN55D 1211 F
R 106	12123080A	RFF 1.21K 500 MW F+-1%	16299	CGW RN55D 1211 F
R 107	12123000A	RFF 1.0 K 500 MW F+-1%	16299	CGW RN55D 1001 F
R 108	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 109	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 110	12121640A	RFF 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 111	12121640A	RFF 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 112	12122800A	RFF 681.0 500 MW F+-1%	16299	CGW RN55D 6810 F
R 113	12123520A	RFF 3.48K 500 MW F+-1%	16299	CGW RN55D 3481 F
R 114	12123520A	RFF 3.48K 500 MW F+-1%	16299	CGW RN55D 3481 F
R 115	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 116	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 117	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 118	12121720A	RFF 56.2 500 MW F+-1%	16299	CGW RN55D 56R2 F
R 119	12121720A	RFF 56.2 500 MW F+-1%	16299	CGW RN55D 56R2 F
R 120	12123560A	RFF 3.83K 500 MW F+-1%	16299	CGW RN55D 3831 F
R 121	12122800A	RFF 681.0 500 MW F+-1%	16299	CGW RN55D 6810 F
R 122	12123000A	RFF 1.0 K 500 MW F+-1%	16299	CGW RN55D 1001 F

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
R 123	09100040A	RVF 100.0 0.5 W M	73138	HEL TYP 72PM
R 124	12123000A	RFF 1.0 K 500 MW F+-1%	16299	CGW RN55D 1001 F
R 125	12121720A	RFF 56.2 500 MW F+-1%	16299	CGW RN55D 56R2 F
R 126	12121720A	RFF 56.2 500 MW F+-1%	16299	CGW RN55D 56R2 F
R 127	12122520A	RFF 348.0 500 MW F+-1%	16299	CGW RN55D 3480 F
R 128	12122520A	RFF 348.0 500 MW F+-1%	16299	CGW RN55D 3480 F
R 129	12122720A	RFF 562.0 500 MW F+-1%	16299	CGW RN55D 5620 F
R 130	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 131	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 132	12122560A	RFF 383.0 500 MW F+-1%	16299	CGW RN55D 3830 F
R 133	12123160A	RFF 1.47K 500 MW F+-1%	16299	CGW RN55D 1471 F
R 134	12122560A	RFF 383.0 500 MW F+-1%	16299	CGW RN55D 3830 F
R 135	12122240A	RFF 178.0 500 MW F+-1%	16299	CGW RN55D 1780 F
R 136	09100040A	RVF 100.0 0.5 W M	73138	HEL TYP 72PM
R 137	12122800A	RFF 681.0 500 MW F+-1%	16299	CGW RN55D 6810 F
R 138	09100230A	RVF 220.0 500.0MW K	73138	HELIPOT TYPE CERMET 72PM
R 139	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 140	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 141	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 142	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 143	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 144	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 145	12123320A	RFF 2.15K 500 MW F+-1%	16299	CGW RN55D 2151 F
R 146	09100060A	RVC 1.0 K 0.5 WK +-10%	73138	HEL TYP 72PM
R 147	12123320A	RFF 2.15K 500 MW F+-1%	16299	CGW RN55D 2151 F
R 148	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 149	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 150	12122400A	RFF 261.0 500 MW F+-1%	16299	CGW RN55D 2610 F
R 151	12122400A	RFF 261.0 500 MW F+-1%	16299	CGW RN55D 2610 F
R 153	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 154	12122560A	RFF 383.0 500 MW F+-1%	16299	CGW RN55D 3830 F
R 155	12122560A	RFF 383.0 500 MW F+-1%	16299	CGW RN55D 3830 F
R 156	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 157	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 158	12122880A	RFF 825.0 500 MW F+-1%	16299	CGW RN55D 8250 F
R 160	12121400A	RFF 26.1 500 MW F+-1%	16299	CGW RN55D 26R1 F
R 163	12127560A	RFF 990.0 K 0.5 W F+- 1%	16299	CGW NA-60
R 165	12121240A	RFF 17.8 500 MW F+-1%	16299	CGW RN55D 17R8 F
R 167	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 168	12121240A	RFF 17.8 500 MW F+-1%	16299	CGW RN55D 17R8 F
R 169	12124000A	RFF 10.0 K 500 MW F+-1%	16299	CGW RN55D 1002 F
R 173	12121520A	RFF 34.8 500 MW F+-1%	16299	CGW RN55D 34R8 F
R 175	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 176	12127570A	RFF 900.0 K 0.5 W F+- 1%	16299	CGW-NA60
R 177	12125040A	RFF 110.0 K 500 MW F+-1%	16299	CGW RN55D 1103 F
R 183	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 184	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 187	12126000A	RFF 1.00M 500 MW F+-1%	16299	CGW RN55D 1004 F
R 189	12125500A	RFF 332.0 K 500 MW F+-1%	16299	CGW RN55D 3323 F
S 10	25100510A	SWC LEVER 1040A/S10	50423	
S 11	25100480A	SWC ROTARY 1040A/S21	50423	
SKY	48100000A	SOC BNC 50 OHMS UG 1094/U	50423	
TR 101	10101240A	TRQ AE 31 DUAL N CHAN FET	50423	
TR 102	10101240A	TRQ AE 31 DUAL N CHAN FET	50423	
TR 103	10100541L	TRQ NPN MATCHED PAIR AE-13	50423	
TR 104	10100541L	TRQ NPN MATCHED PAIR AE-13	50423	
TR 120	10100010A	TRQ 2N2369 NPN 1 15 MT0-18	04713	MCT 1.2 500M 20
TR 121	10100541L	TRQ NPN MATCHED PAIR AE-13	50423	
TR 122	10100541L	TRQ NPN MATCHED PAIR AE-13	50423	

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
TR 123	10100010A	TRQ 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 124	10100010A	TRQ 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 125	10100010A	TRQ 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 126	10100010A	TRQ 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
		DELAY LINE DRIVER AND BEAM SWITCH		
C 200	07095520A	CCD 100 PF 1 KV K 10%	84171	ARC TYP CCD-101
C 201	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 202	07091520A	CVC002.5-11PF 350 V	72982	ERIE NPO 538-D11
C 203	07200050A	CCD 0.1UF 30.0 VK +-10%	71590	CTL CK-104
C 204	07095520A	CCD 100 PF 1 KV K 10%	84171	ARC TYP CCD-101
C 205	07200050A	CCD 0.1UF 30.0 VK +-10%	71590	CTL CK-104
C 206	07091520A	CVC002.5-11PF 350 V	72982	ERIE NPO 538-D11
C 209	07100840A	CCD 15.0PF 500 V	90201	RMC TYPE CG
C 210	07100840A	CCD 15.0PF 500 V	90201	RMC TYPE CG
C 211	07300020A	CVC010.0-40PF TRIMMER	73445	ERIE 538-C110-9-35
C 212	07095730A	CCD 330 PF 500 V K 10%	71590	CTL TYP CE-331
C 213	07095580A	CCD 33.0PF 500.0VK +-10%	56289	SPG TYP C030B102G330K
C 214	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 215	07100840A	CCD 15.0PF 500 V	90201	RMC TYPE CG
C 216	07100840A	CCD 15.0PF 500 V	90201	RMC TYPE CG
C 217	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 218	07095580A	CCD 33.0PF 500.0VK +-10%	56289	SPG TYP C030B102G330K
C 219	07095730A	CCD 330 PF 500 V K 10%	71590	CTL TYP CE-331
C 220	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 221	07250070A	CYM 900.0 PF100.0 VF +-1%	84171	ARCO DM15-911F
C 222	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 223	07200030A	CCD 47.0PF 500.0 VK +-10%	71590	CTL DD-470
C 224	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 225	07200050A	CCD 0.1UF 30.0 VK +-10%	71590	CTL CK-104
C 226	07078350A	CEA 25 UF 25 V T	73445	AMPEREX C426AR/F25
C 227	07022330A	CMM 3.3NF 500.0 VT	09023	CORNELL-DUBLIER 1R5D33
C 228	07078350A	CEA 25 UF 25 V T	73445	AMPEREX C426AR/F25
C 229	07022330A	CMM 3.3NF 500.0 VT	09023	CORNELL-DUBLIER 1R5D33
D 201	05100280A	DGP 1N 916 100 10M	04713	MOT SI D07
D 202	05100280A	DGP 1N 916 100 10M	04713	MOT SI D07
D 203	05100280A	DGP 1N 916 100 10M	04713	MOT SI D07
D 204	05100280A	DGP 1N 916 100 10M	04713	MOT SI D07
D 205	05100280A	DGP 1N 916 100 10M	04713	MOT SI D07
D 206	05100280A	DGP 1N 916 100 10M	04713	MOT SI D07
D 207	05100280A	DGP 1N 916 100 10M	04713	MOT SI D07
D 208	05100280A	DGP 1N 916 100 10M	04713	MOT SI D07
D 209	05100200A	DGP 1N 752A	12954	DIC SI
D 210	05100450A	DTG 1N3506 3.3 20M .4	12954	MOT SI D07
D 211	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 212	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
R 20	09100750A	RVC 470.0 0.5 W R10	50423	
R 26	09100730A	RVC 250.0 0.5 W R26	50423	
R 27	09100730A	RVC 250.0 0.5 W R26	50423	
R 200	12121000A	REF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 201	12121000A	REF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 202	12121000A	REF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
R 203	12122400A	RFF 261.0 500 MW F+-1%	16299	CGW RN55D 2610 F
R 204	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 205	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 206	12122400A	RFF 261.0 500 MW F+-1%	16299	CGW RN55D 2610 F
R 207	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 208	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 209	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 210	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 211	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 212	12121720A	RFF 56.2 500 MW F+-1%	16299	CGW RN55D 56R2 F
R 213	09100040A	RVF 100.0 0.5 W M	73138	HEL TYP 72PM
R 214	12122320A	RFF 215.0 500 MW F+-1%	16299	CGW RN55D 2150 F
R 215	12123320A	RFF 2.15K 500 MW F+-1%	16299	CGW RN55D 2151 F
R 216	12122520A	RFF 348.0 500 MW F+-1%	16299	CGW RN55D 3480 F
R 217	12122240A	RFF 178.0 500 MW F+-1%	16299	CGW RN55D 1780 F
R 218	12122520A	RFF 348.0 500 MW F+-1%	16299	CGW RN55D 3480 F
R 219	12122520A	RFF 348.0 500 MW F+-1%	16299	CGW RN55D 3480 F
R 220	12122240A	RFF 178.0 500 MW F+-1%	16299	CGW RN55D 1780 F
R 221	12122520A	RFF 348.0 500 MW F+-1%	16299	CGW RN55D 3480 F
R 222	12121720A	RFF 56.2 500 MW F+-1%	16299	CGW RN55D 56R2 F
R 223	09100040A	RVF 100.0 0.5 W M	73138	HEL TYP 72PM
R 224	12122320A	RFF 215.0 500 MW F+-1%	16299	CGW RN55D 2150 F
R 225	12123160A	RFF 1.47K 500 MW F+-1%	16299	CGW RN55D 1471 F
R 226	12122800A	RFF 681.0 500 MW F+-1%	16299	CGW RN55D 6810 F
R 227	09100610A	RVF 2.0 K 0.5 W +-30%	73138	HEL TYP 72PM
R 228	12121800A	RFF 68.1 500 MW F+-1%	16299	CGW RN55D 68R1 F
R 229	09100040A	RVF 100.0 0.5 W M	73138	HEL TYP 72PM
R 230	12122320A	RFF 215.0 500 MW F+-1%	16299	CGW RN55D 2150 F
R 231	09100610A	RVF 2.0 K 0.5 W +-30%	73138	HEL TYP 72PM
R 232	12122800A	RFF 681.0 500 MW F+-1%	16299	CGW RN55D 6810 F
R 233	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 234	12121800A	RFF 68.1 500 MW F+-1%	16299	CGW RN55D 68R1 F
R 235	12122410A	RFF 267.0 500 MW F+-1%	16299	CGW RN55D 2670 F
R 236	12121800A	RFF 68.1 500 MW F+-1%	16299	CGW RN55D 68R1 F
R 237	12122640A	RFF 464.0 500 MW F+-1%	16299	CGW RN55D 4640 F
R 238	09100010A	RVC 500.0 0.5 W K	73138	HEL TYP 72PM
R 239	12124520A	RFF 34.8 K 500 MW F+-1%	16299	CGW RN55D 3482 F
R 240	12123240A	RFF 1.78K 500 MW F+-1%	16299	CGW RN55D 1781 F
R 241	12121720A	RFF 56.2 500 MW F+-1%	16299	CGW RN55D 56R2 F
R 242	12123320A	RFF 2.15K 500 MW F+-1%	16299	CGW RN55D 2151 F
R 243	12124160A	RFF 14.7 K 500 MW F+-1%	16299	CGW RN55D 1472 F
R 245	12123560A	RFF 3.83K 500 MW F+-1%	16299	CGW RN55D 3831 F
R 246	12123560A	RFF 3.83K 500 MW F+-1%	16299	CGW RN55D 3831 F
R 247	12122640A	RFF 464.0 500 MW F+-1%	16299	CGW RN55D 4640 F
R 248	12122640A	RFF 464.0 500 MW F+-1%	16299	CGW RN55D 4640 F
R 249	12122520A	RFF 348.0 500 MW F+-1%	16299	CGW RN55D 3480 F
R 250	12122520A	RFF 348.0 500 MW F+-1%	16299	CGW RN55D 3480 F
R 252	12122880A	RFF 825.0 500 MW F+-1%	16299	CGW RN55D 8250 F
R 253	12122880A	RFF 825.0 500 MW F+-1%	16299	CGW RN55D 8250 F
R 254	12121320A	RFF 21.5 500 MW F+-1%	16299	CGW RN55D 21R5 F
R 255	12123240A	RFF 1.78K 500 MW F+-1%	16299	CGW RN55D 1781 F
R 256	12121320A	RFF 21.5 500 MW F+-1%	16299	CGW RN55D 21R5 F
R 257	12123320A	RFF 2.15K 500 MW F+-1%	16299	CGW RN55D 2151 F
R 258	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 259	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 260	12121640A	RFF 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 261	12122080A	RFF 121.0 500 MW F+-1%	16299	CGW RN55D 1210 F
R 262	12122560A	RFF 383.0 500 MW F+-1%	16299	CGW RN55D 3830 F
R 263	12121560A	RFF 38.3 500 MW F+-1%	16299	CGW RN55D 38R3 F
R 264	12121560A	RFF 38.3 500 MW F+-1%	16299	CGW RN55D 38R3 F

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
R 265	12122240A	RES 178.0 500 MW F+-1%	16299	CGW RN55D 1780 F
R 266	12121720A	RES 56.2 500 MW F+-1%	16299	CGW RN55D 56R2 F
R 267	12122160A	RES 147.0 500 MW F+-1%	16299	CGW RN55D 147C F
R 268	12123000A	RES 1.0 K 500 MW F+-1%	16299	CGW RN55D 1001 F
R 269	12123640A	RES 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 270	12122880A	RES 825.0 500 MW F+-1%	16299	CGW RN55D 8250 F
R 271	12123800A	RES 6.81K 500 MW F+-1%	16299	CGW RN55D 6811 F
R 272	12123800A	RES 6.81K 500 MW F+-1%	16299	CGW RN55D 6811 F
R 273	12122880A	RES 825.0 500 MW F+-1%	16299	CGW RN55D 8250 F
R 274	12121000A	RES 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 275	12121000A	RES 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 276	12123640A	RES 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 277	12123000A	RES 1.0 K 500 MW F+-1%	16299	CGW RN55D 1001 F
R 278	12122160A	RES 147.0 500 MW F+-1%	16299	CGW RN55D 1470 F
R 279	12122560A	RES 383.0 500 MW F+-1%	16299	CGW RN55D 3830 F
R 280	12124000A	RES 10.0 K 500 MW F+-1%	16299	CGW RN55D 1002 F
R 281	12123320A	RES 2.15K 500 MW F+-1%	16299	CGW RN55D 2151 F
R 282	12123520A	RES 3.48K 500 MW F+-1%	16299	CGW RN55D 3481 F
R 283	12123560A	RES 3.83K 500 MW F+-1%	16299	CGW RN55D 3831 F
R 284	12123240A	RES 1.78K 500 MW F+-1%	16299	CGW RN55D 1781 F
R 285	12123360A	RES 2.37K 500 MW F+-1%	16299	CGW RN55D 2371 F
R 286	12122640A	RES 464.0 500 MW F+-1%	16299	CGW RN55D 4640 F
R 287	12123400A	RES 2.61K 500 MW F+-1%	16299	CGW RN55D 2611 F
R 288	12121000A	RES 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 289	12121000A	RES 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 290	12121000A	RES 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 291	12121640A	RES 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 292	12121640A	RES 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 294	12121640A	RES 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 295	12121640A	RES 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 296	12122000A	RES 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
S 20	25100510A	SWC LEVER 1040A/S1C	50423	ADV PN/31292
S 21	25100480A	SWC ROTARY 1040A/S21	50423	ADV PN/31276
TR 201	10079340A	TRO 2N3640 PNP 1 12 PTO-18	07263	FCH .500 300M 30
TR 202	10079340A	TRO 2N3640 PNP 1 12 PTO-18	07263	FCH .500 300M 30
TR 203	10079340A	TRO 2N3640 PNP 1 12 PTO-18	07263	FCH .500 300M 30
TR 204	10079340A	TRO 2N3640 PNP 1 12 PTO-18	07263	FCH .500 300M 30
TR 205	10100550A	TRO 2N3640 PNP 1 12 PTO-18	50423	FCH .5 300M 30
TR 206	10100550A	TRO 2N3640 PNP 1 12 PTO-18	50423	FCH .5 300M 30
TR 207	10079340A	TRO 2N3640 PNP 1 12 PTO-18	07263	FCH .500 300M 30
TR 208	10079340A	TRO 2N3640 PNP 1 12 PTO-18	07263	FCH .500 300M 30
TR 209	10100010A	TRO 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 210	10100010A	TRO 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 211	10100010A	TRO 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 212	10079340A	TRO 2N3640 PNP 1 12 PTO-18	07263	FCH .500 300M 30
TR 213	10079340A	TRO 2N3640 PNP 1 12 PTO-18	07263	FCH .500 300M 30
TR 214	10079340A	TRO 2N3640 PNP 1 12 PTO-18	07263	FCH .500 300M 30
TR 215	10100010A	TRO 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 216	10100010A	TRO 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 217	10100010A	TRO 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 218	10100010A	TRO 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C 301	07095790A	CCD 1 NF 150 V K 10%	71590	CTL TYP CE-102
C 302	07081220A	CSM 220 NF 200 V K 10%	73445	AMPEREX TYPE C296
C 303	07102530A	CCD 82.0PF 1.0KVK	56289	SPRAG C028B102E820K OR EQ
C 304	07095790A	CCD 1 NF 150 V K 10%	71590	CTL TYP CE-102
C 305	07200000A	CCD 680.0PF 500.0 VK +-10%	71590	CTL CE-681
C 306	07200040A	CCD 27.0PF 500.0 VK +-10%	71590	CTL DD-270
C 307	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 308	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 309	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 310	07200020A	CCD 39.0PF 500V K+-10%	71590	CTL DD-390
C 311	07300020A	CVC010.0-40PF TRIMMER	73445	ERIE 538-011D-9-35
C 312	07095580A	CCD 33.0PF 500.0VK +-10%	56289	SPG TYP C030B102G330K
C 313	07078220A	CEA 40 UF 16 V K -10+50%	73445	AMPEREX C426AR/E40
C 314	07078220A	CEA 40 UF 16 V K -10+50%	73445	AMPEREX C426AR/E40
C 315	07095790A	CCD 1 NF 150 V K 10%	71590	CTL TYP CE-102
C 316	07095790A	CCD 1 NF 150 V K 10%	71590	CTL TYP CE-102
C 317	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 318	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 319	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 320	07200040A	CCD 27.0PF 500.0 VK +-10%	71590	CTL DD-270
C 351	07200000A	CCD 680.0PF 500.0 VK +-10%	71590	CTL CE-681
C 352	07095520A	CCD 100 PF 1 KV K 10%	84171	ARC TYP CCD-101
C 353	07095520A	CCD 100 PF 1 KV K 10%	84171	ARC TYP CCD-101
C 354	07250000A	CYM 0.1 UF400.0 VK +-20%	56289	418P10404LA3 RADIAL LEADS
C 355	07250000A	CYM 0.1 UF400.0 VK +-20%	56289	418P10404LA3 RADIAL LEADS
C 356	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 357	07300020A	CVC010.0-40PF TRIMMER	73445	ERIE 538-011D-9-35
C 358	07101970A	CCD 33.0PF 1.0KVJ NPO	56289	SPRAGUE C03CB1C2G330J EQV
D 300	05100440A	DZG 1N3508 3.9 20M .4	12954	MOT SI DO7
D 351	05100450A	DZG 1N3506 3.3 20M .4	12954	MOT SI DO7
L 351	03062890A	CLF 3.3UH	83125	NYTRONICS, DD-3.3
L 352	03062890A	CLF 3.3UH	83125	NYTRONICS, DD-3.3
R 300	12123160A	RFF 1.47K 500 MW F+-1%	16299	CGW RN55D 1471 F
R 301	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 302	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 303	12123520A	RFF 3.48K 500 MW F+-1%	16299	CGW RN55D 3481 F
R 304	12121320A	RFF 21.5 500 MW F+-1%	16299	CGW RN55D 21R5 F
R 305	12121320A	RFF 21.5 500 MW F+-1%	16299	CGW RN55D 21R5 F
R 306	12122560A	RFF 383.0 500 MW F+-1%	16299	CGW RN55D 3830 F
R 307	12122560A	RFF 383.0 500 MW F+-1%	16299	CGW RN55D 3830 F
R 308	12123880A	RFF 8.25K 500 MW F+-1%	16299	CGW RN55D 8251 F
R 309	09100650A	RVF 25.0 K 0.5 W +-10%	73138	HELIPOT 72P TRIMPOT MINI
R 310	12124320A	RFF 21.5 K 500 MW F+-1%	16299	CGW RN55D 2152 F
R 311	09100080A	RVC 10.0 K 0.5 WK +-10%	73138	HEL TYP 72PM
R 312	12122560A	RFF 383.0 500 MW F+-1%	16299	CGW RN55D 3830 F
R 313	12121560A	RFF 38.3 500 MW F+-1%	16299	CGW RN55D 38R3 F
R 314	12121560A	RFF 38.3 500 MW F+-1%	16299	CGW RN55D 38R3 F
R 315	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 316	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 317	12122680A	RFF 511.0 500 MW F+-1%	16299	CGW RN55D 5110 F
R 318	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 319	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 320	12121640A	RFF 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 321	12121320A	RFF 21.5 500 MW F+-1%	16299	CGW RN55D 21R5 F
R 322	12121320A	RFF 21.5 500 MW F+-1%	16299	CGW RN55D 21R5 F
R 323	12121320A	RFF 21.5 500 MW F+-1%	16299	CGW RN55D 21R5 F
R 324	09100010A	RVC 500.0 0.5 W K	73138	HEL TYP 72PM
R 325	12123520A	RFF 3.48K 500 MW F+-1%	16299	CGW RN55D 3481 F
R 326	12123520A	RFF 3.48K 500 MW F+-1%	16299	CGW RN55D 3481 F
R 327	12121720A	RFF 56.2 500 MW F+-1%	16299	CGW RN55D 56R2 F
R 328	12121720A	RFF 56.2 500 MW F+-1%	16299	CGW RN55D 56R2 F

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
R 329	12122720A	RFF 562.0 500 MW F+-1%	16299	CGW RN55D 5620 F
R 330	12122560A	RFF 383.0 500 MW F+-1%	16299	CGW RN55D 3830 F
R 331	12122560A	RFF 383.0 500 MW F+-1%	16299	CGW RN55D 3830 F
R 332	12122320A	RFF 215.0 500 MW F+-1%	16299	CGW RN55D 2150 F
R 333	12122400A	RFF 261.0 500 MW F+-1%	16299	CGW RN55D 2610 F
R 334	12122400A	RFF 261.0 500 MW F+-1%	16299	CGW RN55D 2610 F
R 335	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 336	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 337	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 338	12125000A	RFF 100.0 K 500 MW F+-1%	16299	CGW RN55D 1003 F
R 339	12123520A	RFF 3.48K 500 MW F+-1%	16299	CGW RN55D 3481 F
R 351	12123320A	RFF 2.15K 500 MW F+-1%	16299	CGW RN55D 2151 F
R 352	12121640A	RFF 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 353	12121560A	RFF 38.3 500 MW F+-1%	16299	CGW RN55D 38R3 F
R 354	12121720A	RFF 56.2 500 MW F+-1%	16299	CGW RN55D 56R2 F
R 355	12121720A	RFF 56.2 500 MW F+-1%	16299	CGW RN55D 56R2 F
R 356	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 357	09100040A	RVF 100.0 0.5 W M	73138	HEL TYP 72PM
R 358	12124320A	RFF 21.5 K 500 MW F+-1%	16299	CGW RN55D 2152 F
R 359	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 360	12121880A	RFF 82.5 500 MW F+-1%	16299	CGW RN55D 82R5 F
R 361	12121880A	RFF 82.5 500 MW F+-1%	16299	CGW RN55D 82R5 F
R 362	12121720A	RFF 56.2 500 MW F+-1%	16299	CGW RN55D 56R2 F
R 363	12121720A	RFF 56.2 500 MW F+-1%	16299	CGW RN55D 56R2 F
R 364	12121720A	RFF 56.2 500 MW F+-1%	16299	CGW RN55D 56R2 F
R 365	12012720A	RFC 1.0 K 1.0 W J+- 5%	01121	A-B TYP GB
R 366	12012720A	RFC 1.0 K 1.0 W J+- 5%	01121	A-B TYP GB
R 367	12012720A	RFC 1.0 K 1.0 W J+- 5%	01121	A-B TYP GB
R 368	12012720A	RFC 1.0 K 1.0 W J+- 5%	01121	A-B TYP GB
R 369	12012720A	RFC 1.0 K 1.0 W J+- 5%	01121	A-B TYP GB
R 370	12012720A	RFC 1.0 K 1.0 W J+- 5%	01121	A-B TYP GB
R 371	12012720A	RFC 1.0 K 1.0 W J+- 5%	01121	A-B TYP GB
R 372	12012720A	RFC 1.0 K 1.0 W J+- 5%	01121	A-B TYP GB
R 373	12127480A	RFW 2.2 K 5.25W J+- 5%	44653	OHMITE 2000 CAT#2902
R 374	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 380	12124720A	RFF 56.2 K 500 MW F+-1%	16299	CGW RN55D 5622 F
R 381	09100660A	RVF 100.0 K .5 W +-10%	73138	HELIPOT 72P TRIMPOT MINI
R 382	12125080A	RFF 121.0 K 500 MW F+-1%	16299	CGW RN55D 1213 F
R 383	12127480A	RFW 2.2 K 5.25W J+- 5%	44653	OHMITE 2000 CAT#2902
TR 300	10079340A	TRQ 2N3640 PNP 1 12 PTO-18	07263	FCH .500 300M 30
TR 301	10079340A	TRQ 2N3640 PNP 1 12 PTO-18	07263	FCH .500 300M 30
TR 302	10100010A	TRQ 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 303	10100010A	TRQ 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 304	10100010A	TRQ 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 305	10100010A	TRQ 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 351	10100010A	TRQ 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 352	10100010A	TRQ 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 353	10100510A	TRQ 2N3119 NPN 1 80 MTO-5	04713	RCA 1 250M 40
TR 354	10100510A	TRQ 2N3119 NPN 1 80 MTO-5	04713	RCA 1 250M 40
TR 355	10100010A	TRQ 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C 400	07025060A	CCT 4.7PF T	78488	STACKPOLE TYPE GA-6
C 401	07104170A	CCD 180.0PF 600.0 VK	71590	CTL DD-181
C 402	07101640A	CCD 470.0NF 100.0 V GMV	72982	ERIE 8131-100 651 474M
C 403	07022920A	CMD 470.0PF 500.0 V J+- 5%	84171	ARCO DM-15-471-J
C 404	07095580A	CCD 33.0PF 500.0VK +-10%	56289	SPG TYP C030B102G330K
C 405	07095520A	CCD 100 PF 1 KV K 10%	84171	ARC TYP CCD-101
C 406	07095510A	CCD 10 PF 1 KV K 10%	84171	ARC TYP CCD-100
C 407	07095580A	CCD 33.0PF 500.0VK +-10%	56289	SPG TYP C030B102G330K
C 408	07200030A	CCD 47.0PF 500.0 VK +-10%	71590	CTL DD-470
C 409	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 410	07101700A	CCD 1.0NF 1.0KV 10%	71590	CENTRALAB DD102
C 411	07101630A	CCD 0.1UF 100.0 V GMV	72982	ERIE 7060-100/651-104M
C 412	07101630A	CCD 0.1UF 100.0 V GMV	72982	ERIE 7060-100/651-104M
C 413	07095520A	CCD 100 PF 1 KV K 10%	84171	ARC TYP CCD-101
C 414	07101700A	CCD 1.0NF 1.0KV 10%	71590	CENTRALAB DD102
C 415	07095750A	CCD 220 PF 600 V K 10%	71590	CTL TYP DD-721
C 416	07025680A	CCD 330 NF 25 V M+-20%	56289	SPRAGUE 2C023334XC250A3
C 417	07200050A	CCD 0.1UF 30.0 VK +-10%	71590	CTL CK-104
C 418	07101630A	CCD 0.1UF 100.0 V GMV	72982	ERIE 7060-100/651-104M
C 419	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 420	07200060A	CCD 22.0PF 500.0 VK N330	71590	CTL DD-220
C 421	07200050A	CCD 0.1UF 30.0 VK +-10%	71590	CTL CK-104
C 422	07200050A	CCD 0.1UF 30.0 VK +-10%	71590	CTL CK-104
C 423	07095790A	CCD 1 NF 150 V K 10%	71590	CTL TYP CE-102
C 424	07104310A	CCD 390.0PF 110KVK	71590	CTL DD-391
C 425	07078350A	CEA 25 UF 25 V T	73445	AMPEREX C426AR/F25
C 427	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 428	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 429	07025020A	CCT 1.5PF T	78488	STACKPOLE TYPE GA-3
C 430	07095510A	CCD 10 PF 1 KV K 10%	84171	ARC TYP CCD-100
C 431	07200080A	CCD 18.0PF 150.0 V	71590	CTL DD-180
C 432	07101530A	CCD 6.8PF 500.0 V NPO+-1PF	72982	ERIE 801 NPO 6.8PF 1P500V
C 433	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 434	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 435	07300010A	CVC005.5-25PF 350 V	72982	TYP 538-014,D,5.5-25
C 436	07095520A	CCD 100 PF 1 KV K 10%	84171	ARC TYP CCD-101
C 437	07095520A	CCD 100 PF 1 KV K 10%	84171	ARC TYP CCD-101
C 438	07095520A	CCD 100 PF 1 KV K 10%	84171	ARC TYP CCD-101
C 439	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 440	07095580A	CCD 33.0PF 500.0VK +-10%	56289	SPG TYP C030B102G330K
C 441	07200050A	CCD 0.1UF 30.0 VK +-10%	71590	CTL CK-104
C 444	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 445	07101630A	CCD 0.1UF 100.0 V GMV	72982	ERIE 7060-100/651-104M
C 446	07200050A	CCD 0.1UF 30.0 VK +-10%	71590	CTL CK-104
C 447	07095750A	CCD 220 PF 600 V K 10%	71590	CTL TYP DD-721
C 448	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 449	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 450	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 451	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 452	07078220A	CEA 40 UF 16 V K -10+50%	73445	AMPEREX C426AR/E40
C 453	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 454	07095790A	CCD 1 NF 150 V K 10%	71590	CTL TYP CE-102
C 455	07200060A	CCD 22.0PF 500.0 VK N330	71590	CTL DD-220
D 401	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 402	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 403	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 404	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 405	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 406	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 407	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
D 408	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 409	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 410	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 411	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 412	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 413	05100280A	DGP IN 916 100 10M	04713	MOT SI D07 4 2
D 414	05100040A	DGP OA47 25 150M	12954	AMP GE D07 70 3.5
D 415	05100040A	DGP OA47 25 150M	12954	AMP GE D07 70 3.5
D 416	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 417	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 418	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 419	05100140A	DGP 1N4006 20 20M	15238	SEE 05-C8058-0A
D 420	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 421	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 422	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 423	05100220A	DZG 1N4763 91 2.8M 1	04713	MOT SI D041
D 424	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 425	05100040A	DGP OA47 25 150M	12954	AMP GE D07 70 3.5
D 426	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 427	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 428	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 429	05100010A	DGP 1N3595 150 150M .5	12954	FCH SI D07 3 8
D 431	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 432	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 433	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 434	05100100A	DZG 1N 750A 4.7 20M .4	04713	MOT SI
D 435	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 436	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 437	05100280A	DGP IN 916 100 10M	04713	MOT SI D07 4 2
D 438	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 439	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 440	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
IC 400	24094070A	ICP T.I. SN7400N OR	56289	SPRAGUE USN7400A
L 400	03100000A	CRF 15UH INDUCTOR PEAKING	83125	NYTRONICS DD-15.0
L 402	46100000A	FRB FERRITE BEAD	78488	STACKPOLE 57-0180-7D MAT
N 400	16100000A	LMP PAN GALIUM ARSENIDE	28480	(HP)-5082-4440
R 400	12121640A	RFF 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 401	12125000A	RFF 100.0 K 500 MW F+-1%	16299	CGW RN55D 1003 F
R 402	12123320A	RFF 2.15K 500 MW F+-1%	16299	CGW RN55D 2151 F
R 403	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 404	12121640A	RFF 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 405	12121640A	RFF 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 406	12121640A	RFF 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 407	12121640A	RFF 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 408	12123160A	RFF 1.47K 500 MW F+-1%	16299	CGW RN55D 1471 F
R 409	12124000A	RFF 10.0 K 500 MW F+-1%	16299	CGW RN55D 1002 F
R 410	12123000A	RFF 1.0 K 500 MW F+-1%	16299	CGW RN55D 1001 F
R 411	12123560A	RFF 3.83K 500 MW F+-1%	16299	CGW RN55D 3831 F
R 412	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 413	12123400A	RFF 2.61K 500 MW F+-1%	16299	CGW RN55D 2611 F
R 414	12122320A	RFF 215.0 500 MW F+-1%	16299	CGW RN55D 2150 F
R 415	12123160A	RFF 1.47K 500 MW F+-1%	16299	CGW RN55D 1471 F
R 416	12122720A	RFF 562.0 500 MW F+-1%	16299	CGW RN55D 5620 F
R 417	12123880A	RFF 8.25K 500 MW F+-1%	16299	CGW RN55D 8251 F
R 418	12125640A	RFF 464.0 K 500 MW F+-1%	16299	CGW RN55D 4643 F
R 419	12123320A	RFF 2.15K 500 MW F+-1%	16299	CGW RN55D 2151 F
R 420	12124000A	RFF 10.0 K 500 MW F+-1%	16299	CGW RN55D 1002 F
R 421	12125320A	RFF 215.0 K 500 MW F+-1%	16299	CGW RN55D 2153 F
R 422	12124520A	RFF 34.8 K 500 MW F+-1%	16299	CGW RN55D 3482 F
R 423	12124320A	RFF 21.5 K 500 MW F+-1%	16299	CGW RN55D 2152 F

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
R 424	12123240A	RFF 1.78K 500 MW F+-1%	16299	CGW RN55D 1781 F
R 425	12124520A	RFF 34.8 K 500 MW F+-1%	16299	CGW RN55D 3482 F
R 426	12123000A	RFF 1.0 K 500 MW F+-1%	16299	CGW RN55D 1001 F
R 427	12123000A	RFF 1.0 K 500 MW F+-1%	16299	CGW RN55D 1001 F
R 428	12125000A	RFF 100.0 K 500 MW F+-1%	16299	CGW RN55D 1003 F
R 429	12122640A	RFF 464.0 500 MW F+-1%	16299	CGW RN55D 4640 F
R 430	12125720A	RFF 562.0 K 500 MW F+-1%	16299	CGW RN55D 5623 F
R 431	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 432	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 433	12125160A	RFF 147.0 K 500 MW F+-1%	16299	CGW RN55D 1473 F
R 434	12123560A	RFF 3.83K 500 MW F+-1%	16299	CGW RN55D 3831 F
R 435	12121560A	RFF 38.3 500 MW F+-1%	16299	CGW RN55D 38R3 F
R 436	12121640A	RFF 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 437	12124080A	RFF 12.1 K 500 MW F+-1%	16299	CGW RN55D 1212 F
R 438	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 439	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 440	09100780A	RVC 100.0 K 0.5 W	50423	
R 441	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 442	12121320A	RFF 21.5 500 MW F+-1%	16299	CGW RN55D 21R5 F
R 443	12123520A	RFF 3.48K 500 MW F+-1%	16299	CGW RN55D 3481 F
R 444	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 445	12123160A	RFF 1.47K 500 MW F+-1%	16299	CGW RN55D 1471 F
R 446	12124320A	RFF 21.5 K 500 MW F+-1%	16299	CGW RN55D 2152 F
R 447	12124520A	RFF 34.8 K 500 MW F+-1%	16299	CGW RN55D 3482 F
R 448	12125640A	RFF 464.0 K 500 MW F+-1%	16299	CGW RN55D 4643 F
R 449	12124080A	RFF 12.1 K 500 MW F+-1%	16299	CGW RN55D 1212 F
R 450	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 451	12121640A	RFF 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 452	12122800A	RFF 681.0 500 MW F+-1%	16299	CGW RN55D 6810 F
R 453	09100060A	RVC 1.0 K 0.5 WK +-10%	73138	HEL TYP 72PM
R 454	12123120A	RFF 1.33K 500 MW F+-1%	16299	CGW RN55D 1331 F
R 455	12123520A	RFF 3.48K 500 MW F+-1%	16299	CGW RN55D 3481 F
R 456	12123160A	RFF 1.47K 500 MW F+-1%	16299	CGW RN55D 1471 F
R 457	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 458	12122640A	RFF 464.0 500 MW F+-1%	16299	CGW RN55D 4640 F
R 459	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 460	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 461	12122520A	RFF 348.0 500 MW F+-1%	16299	CGW RN55D 3480 F
R 462	12124520A	RFF 34.8 K 500 MW F+-1%	16299	CGW RN55D 34R2 F
R 463	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 464	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 465	12122880A	RFF 825.0 500 MW F+-1%	16299	CGW RN55D 8250 F
R 466	12124320A	RFF 21.5 K 500 MW F+-1%	16299	CGW RN55D 2152 F
R 467	12122640A	RFF 464.0 500 MW F+-1%	16299	CGW RN55D 4640 F
R 468	12122320A	RFF 215.0 500 MW F+-1%	16299	CGW RN55D 2150 F
R 469	12122640A	RFF 464.0 500 MW F+-1%	16299	CGW RN55D 4640 F
R 470	12122560A	RFF 383.0 500 MW F+-1%	16299	CGW RN55D 3830 F
R 471	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 472	12123400A	RFF 2.61K 500 MW F+-1%	16299	CGW RN55D 2611 F
R 473	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 474	12122320A	RFF 215.0 500 MW F+-1%	16299	CGW RN55D 2150 F
R 475	12123000A	RFF 1.0 K 500 MW F+-1%	16299	CGW RN55D 1001 F
R 476	12123160A	RFF 1.47K 500 MW F+-1%	16299	CGW RN55D 1471 F
R 477	12121880A	RFF 82.5 500 MW F+-1%	16299	CGW RN55D 82R5 F
R 478	12123080A	RFF 1.21K 500 MW F+-1%	16299	CGW RN55D 1211 F
R 479	12123880A	RFF 8.25K 500 MW F+-1%	16299	CGW RN55D 8251 F
R 481	12125240A	RFF 178.0 K 500 MW F+-1%	16299	CGW RN55D 1783 F
R 482	12123080A	RFF 1.21K 500 MW F+-1%	16299	CGW RN55D 1211 F
R 483	12124320A	RFF 21.5 K 500 MW F+-1%	16299	CGW RN55D 2152 F
R 484	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F

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R 485	12122880A	RFF 825.0 500 MW F+-1%	16299	CGW RN55D 8250 F
R 486	12124320A	RFF 21.5 K 500 MW F+-1%	16299	CGW RN55D 2152 F
R 487	12123250A	RFF 1.82K 500 MW F+-1%	16299	CGW RN55D 1821 F
R 488	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 489	12122840A	RFF 750.0 500 MW F+-1%	16299	CGW RN55D 7500 F
R 490	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 491	12122640A	RFF 464.0 500 MW F+-1%	16299	CGW RN55D 4640 F
R 492	12123320A	RFF 2.15K 500 MW F+-1%	16299	CGW RN55D 2151 F
R 493	12122880A	RFF 825.0 500 MW F+-1%	16299	CGW RN55D 8250 F
R 494	12125000A	RFF 100.0 K 500 MW F+-1%	16299	CGW RN55D 1003 F
R 495	12123160A	RFF 1.47K 500 MW F+-1%	16299	CGW RN55D 1471 F
R 496	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 497	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 498	12125080A	RFF 121.0 K 500 MW F+-1%	16299	CGW RN55D 1213 F
R 499	12123880A	RFF 8.25K 500 MW F+-1%	16299	CGW RN55D 8251 F
R 500	12123800A	RFF 6.81K 500 MW F+-1%	16299	CGW RN55D 6811 F
R 501	12122880A	RFF 825.0 500 MW F+-1%	16299	CGW RN55D 8250 F
R 502	12125000A	RFF 100.0 K 500 MW F+-1%	16299	CGW RN55D 1003 F
R 503	12123880A	RFF 8.25K 500 MW F+-1%	16299	CGW RN55D 8251 F
R 504	12123520A	RFF 3.48K 500 MW F+-1%	16299	CGW RN55D 3481 F
R 505	12123080A	RFF 1.21K 500 MW F+-1%	16299	CGW RN55D 1211 F
R 506	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 507	09100770A	RVC 10.0 K 0.5 W	50473	
R 508	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 509	12123080A	RFF 1.21K 500 MW F+-1%	16299	CGW RN55D 1211 F
R 510	09100010A	RVC 500.0 0.5 W K	73138	HEL TYP 72PM
R 511	12124000A	RFF 10.0 K 500 MW F+-1%	16299	CGW RN55D 1002 F
R 512	12123520A	RFF 3.48K 500 MW F+-1%	16299	CGW RN55D 3481 F
R 513	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 514	12123520A	RFF 3.48K 500 MW F+-1%	16299	CGW RN55D 3481 F
R 515	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 516	12124000A	RFF 10.0 K 500 MW F+-1%	16299	CGW RN55D 1002 F
R 517	12124000A	RFF 10.0 K 500 MW F+-1%	16299	CGW RN55D 1002 F
R 518	12123880A	RFF 8.25K 500 MW F+-1%	16299	CGW RN55D 8251 F
R 519	12124000A	RFF 10.0 K 500 MW F+-1%	16299	CGW RN55D 1002 F
R 520	12124000A	RFF 10.0 K 500 MW F+-1%	16299	CGW RN55D 1002 F
R 521	12124000A	RFF 10.0 K 500 MW F+-1%	16299	CGW RN55D 1002 F
R 522	12124000A	RFF 10.0 K 500 MW F+-1%	16299	CGW RN55D 1002 F
R 523	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 524	12124640A	RFF 46.4 K 500 MW F+-1%	16299	CGW RN55D 4642 F
R 525	12123800A	RFF 6.81K 500 MW F+-1%	16299	CGW RN55D 6811 F
R 526	12122640A	RFF 464.0 500 MW F+-1%	16299	CGW RN55D 4640 F
R 527	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 528	12124160A	RFF 14.7 K 500 MW F+-1%	16299	CGW RN55D 1472 F
R 529	12123160A	RFF 1.47K 500 MW F+-1%	16299	CGW RN55D 1471 F
R 530	12124000A	RFF 10.0 K 500 MW F+-1%	16299	CGW RN55D 1002 F
R 531	12124640A	RFF 46.4 K 500 MW F+-1%	16299	CGW RN55D 4642 F
R 532	12122560A	RFF 383.0 500 MW F+-1%	16299	CGW RN55D 3830 F
R 533	12123800A	RFF 6.81K 500 MW F+-1%	16299	CGW RN55D 6811 F
R 534	12123000A	RFF 1.0 K 500 MW F+-1%	16299	CGW RN55D 1001 F
R 535	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 536	12123000A	RFF 1.0 K 500 MW F+-1%	16299	CGW RN55D 1001 F
R 537	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 538	12060640A	RCF 10.0 M 500.0 MW F+- 1%	35929	ODN TYP N4
R 539	12121640A	RFF 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 540	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 541	12124000A	RFF 10.0 K 500 MW F+-1%	16299	CGW RN55D 1002 F
R 542	12123800A	RFF 6.81K 500 MW F+-1%	16299	CGW RN55D 6811 F
R 543	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 544	12123080A	RFF 1.21K 500 MW F+-1%	16299	CGW RN55D 1211 F
R 545	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F

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R 546	12121640A	RES 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 547	12121640A	RES 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 548	12125000A	RES 100.0 K 500 MW F+-1%	16299	CGW RN55D 1003 F
R 549	12123560A	RES 3.83K 500 MW F+-1%	16299	CGW RN55D 3831 F
R 550	12121000A	RES 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 551	12122560A	RES 383.0 500 MW F+-1%	16299	CGW RN55D 3830 F
R 552	12125000A	RES 100.0 K 500 MW F+-1%	16299	CGW RN55D 1003 F
R 553	12123280A	RES 1.96K 500 MW F+-1%	16299	CGW RN55D 1961 F
R 554	12122800A	RES 681.0 500 MW F+-1%	16299	CGW RN55D 6810 F
R 555	12123000A	RES 1.0 K 500 MW F+-1%	16299	CGW RN55D 1001 F
R 556	12123240A	RES 1.78K 500 MW F+-1%	16299	CGW RN55D 1781 F
R 557	12121520A	RES 34.8 500 MW F+-1%	16299	CGW RN55D 34R8 F
R 558	12121640A	RES 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 559	12122000A	RES 100.0 500 MW F+-1%	16299	CGW RN55D 100C F
R 560	12124640A	RES 46.4 K 500 MW F+-1%	16299	CGW RN55D 4642 F
R 571	12121320A	RES 21.5 500 MW F+-1%	16299	CGW RN55D 21R5 F
R 572	12122640A	RES 464.0 500 MW F+-1%	16299	CGW RN55D 4640 F
R 573	12123600A	RES 4.22K 500 MW F+-1%	16299	CGW RN55D 4221 F
R 574	12123560A	RES 3.83K 500 MW F+-1%	16299	CGW RN55D 3831 F
R 575	12121650A	RES 47.5 500 MW F+-1%	16299	CGW RN55D 48R5 F
S 40	25100940A	SWC 1040A S40 A TRIG SELCT	50423	
S 41	09100780A	RVC 100.0 K 0.5 W	50423	
S 42	25100960A	SWC 1040A S42 ACDCTVAC4LEVER	50423	
S 44	25100970A	SWC 1040A S44 SWEEP 3-LEVER	50423	
SKE	31033790A	CON UG-1094/U BNC,DAGE	29587	STATE ELECT.PARTS
TR 401	10100010A	TRO 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 402	10100010A	TRO 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 403	10100020A	TRO 2N 930 NPN 1 45 MTO-18	04713	MOT 1.8 30M 40
TR 404	10094730A	TRO 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
TR 405	10100020A	TRO 2N 930 NPN 1 45 MTO-18	04713	MOT 1.8 30M 40
TR 406	10094730A	TRO 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
TR 407	10100020A	TRO 2N 930 NPN 1 45 MTO-18	04713	MOT 1.8 30M 40
TR 408	10094730A	TRO 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
TR 409	10100020A	TRO 2N 930 NPN 1 45 MTO-18	04713	MOT 1.8 30M 40
TR 410	10094730A	TRO 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
TR 411	10094730A	TRO 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
TR 412	10100020A	TRO 2N 930 NPN 1 45 MTO-18	04713	MOT 1.8 30M 40
TR 413	10100541L	TRO NPN MATCHED PAIR AE-13	50423	
TR 414	10100541L	TRO NPN MATCHED PAIR AE-13	50423	
TR 415	10079340A	TRO 2N3640 PNP 1 12 PTO-18	07263	FCH .500 300M 30
TR 416	10079340A	TRO 2N3640 PNP 1 12 PTO-18	07263	FCH .500 300M 30
TR 417	10100010A	TRO 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 418	10100020A	TRO 2N 930 NPN 1 45 MTO-18	04713	MOT 1.8 30M 40
TR 419	10100010A	TRO 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 420	10100010A	TRO 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 421	10094730A	TRO 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
TR 422	10094730A	TRO 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
TR 423	10100020A	TRO 2N 930 NPN 1 45 MTO-18	04713	MOT 1.8 30M 40
TR 424	10100020A	TRO 2N 930 NPN 1 45 MTO-18	04713	MOT 1.8 30M 40
TR 425	10101240A	TRO AE 31 DUAL N CHAN FET	50423	
TR 426	10101240A	TRO AE 31 DUAL N CHAN FET	50423	
TR 427	10100020A	TRO 2N 930 NPN 1 45 MTO-18	04713	MOT 1.8 30M 40
TR 428	10094730A	TRO 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
TR 429	10100541L	TRO NPN MATCHED PAIR AE-13	50423	
TR 430	10094730A	TRO 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
TR 431	10079340A	TRO 2N3640 PNP 1 12 PTO-18	07263	FCH .500 300M 30
TR 432	10094730A	TRO 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
TR 433	10100110A	TRO 2N5831 NPN 1 140 PTO-92	07263	FCH 1 100M 80
TR 434	10079340A	TRO 2N3640 PNP 1 12 PTO-18	07263	FCH .500 300M 30
TR 435	10100010A	TRO 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 436	10100541L	TRO NPN MATCHED PAIR AE-13	50423	
TR 437	10100010A	TRO 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 438	10100010A	TRO 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C 601	07025060A	CCT 4.7PF T	78488	STACKPOLE TYPE GA-6
C 602	07095750A	CCD 220 PF 600 V K 10%	71590	CTL TYP DD-721
C 603	07095510A	CCD 10 PF 1 KV K 10%	84171	ARC TYP CCD-100
C 604	07095510A	CCD 10 PF 1 KV K 10%	84171	ARC TYP CCD-100
C 605	07095520A	CCD 100 PF 1 KV K 10%	84171	ARC TYP CCD-101
C 606	07101540A	CCD 8.2PF 500.0 V NPO+-1PF	72982	ERIE 831 NPO 8.2PF 1P500V
C 607	07095510A	CCD 10 PF 1 KV K 10%	84171	ARC TYP CCD-100
C 608	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 609	07200030A	CCD 47.0PF 500.0 VK +-10%	71590	CTL DD-470
C 610	07022920A	CMD 470.0PF 500.0 V J+- 5%	84171	ARCO DM-15-471-J
C 611	07023920A	CSM 470 NF 200 V J 5%	56289	SPRAGUE TYPE 148P47452
C 612	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 613	07200050A	CCD 0.1UF 30.0 VK +-10%	71590	CTL CK-104
C 614	07200050A	CCD 0.1UF 30.0 VK +-10%	71590	CTL CK-104
C 615	07200050A	CCD 0.1UF 30.0 VK +-10%	71590	CTL CK-104
C 616	07101700A	CCD 1.0NF 1.0KV 10%	71590	CENTRALAB DD102
C 617	07101700A	CCD 1.0NF 1.0KV 10%	71590	CENTRALAB DD102
C 618	07101700A	CCD 1.0NF 1.0KV 10%	71590	CENTRALAB DD102
C 619	07104310A	CCD 390.0PF 110KVK	71590	CTL DD-391
C 620	07200060A	CCD 22.0PF 500.0 VK N330	71590	CTL DD-220
C 621	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 623	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 624	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 625	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 626	07200060A	CCD 22.0PF 500.0 VK N330	71590	CTL DD-220
C 627	07095510A	CCD 10 PF 1 KV K 10%	84171	ARC TYP CCD-100
C 628	07200080A	CCD 18.0PF 150.0 V	71590	CTL DD-180
C 629	07200080A	CCD 18.0PF 150.0 V	71590	CTL DD-180
C 630	07095580A	CCD 33.0PF 500.0VK +-10%	56289	SPG TYP C030B102G330K
C 631	07300010A	CVC005.5-25PF 350 V	72982	TYP 538-014,D,5.5-25
C 632	07025980A	CCT 4.7PF 500 V J+- 5%	95121	QUALITY COMPONENTS TP QC
C 633	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 634	07023750A	CSM 330 NF 200 V M 20%	92741	GOODALL TYPE 663-UW
C 635	07078350A	CEA 25 UF 25 V T	73445	AMPEREX C426AR/E25
C 636	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 637	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 638	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 639	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 640	07095580A	CCD 33.0PF 500.0VK +-10%	56289	SPG TYP C030B102G330K
C 641	07095730A	CCD 330 PF 500 V K 10%	71590	CTL TYP CE-331
C 642	07095730A	CCD 330 PF 500 V K 10%	71590	CTL TYP CE-331
C 643	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 644	07200050A	CCD 0.1UF 30.0 VK +-10%	71590	CTL CK-104
C 645	07300010A	CVC005.5-25PF 350 V	72982	TYP 538-014,D,5.5-25
C 646	07078220A	CEA 40 UF 16 V K -10+50%	73445	AMPEREX C426AP/E40
C 647	07200050A	CCD 0.1UF 30.0 VK +-10%	71590	CTL CK-104
C 648	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 655	07095790A	CCD 1 NF 150 V K 10%	71590	CTL TYP CE-102
C 656	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
D 600	05100010A	DGP 1N3595 150 150M .5	12954	FCH SI D07 3 R
D 601	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 602	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 603	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 604	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 605	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 606	05079100A	DZP 1N 957B 6.8 1PM	27832	FCH SI D07 ZENER DIODE
D 607	05100030A	DZG 1N 959B 8.2 15M .4	12954	DIC SI D07
D 608	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 609	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 610	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
D 611	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 612	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 613	05100010A	DGP 1N3595 150 150M .5	12954	FCH SI D07 3 8
D 614	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 615	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 616	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 617	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 618	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 619	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 620	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 621	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 622	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 623	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 624	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 625	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 626	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 627	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 628	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 629	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 630	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 631	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 632	05100280A	DGP 1N 916 100 10M	04713	MOT SI D07 4 2
D 633	05100280A	DGP 1N 916 100 10M	04713	MOT SI D07 4 2
D 634	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
L 601	46100000A	FRB FERRITE BEAD	78488	STACKPOLE 57-0180-7D MAT
L 602	46100000A	FRB FERRITE BEAD	78488	STACKPOLE 57-0180-7D MAT
L 603	46100000A	FRB FERRITE BEAD	78488	STACKPOLE 57-0180-7D MAT
R 600	12123560A	RFF 3.83K 500 MW F+-1%	16299	CGW RN55D 3831 F
R 601	12125000A	RFF 100.0 K 500 MW F+-1%	16299	CGW RN55D 1003 F
R 602	09100131A	RVC 0.5 W	50423	CTS 45 BACKLASH ADV 29553
R 603	09100131A	RVC 0.5 W	50423	CTS 45 BACKLASH ADV 29553
R 604	12123160A	RFF 1.47K 500 MW F+-1%	16299	CGW RN55D 1471 F
R 605	12123560A	RFF 3.83K 500 MW F+-1%	16299	CGW RN55D 3831 F
R 606	12123560A	RFF 3.83K 500 MW F+-1%	16299	CGW RN55D 3831 F
R 607	12123000A	RFF 1.0 K 500 MW F+-1%	16299	CGW RN55D 1001 F
R 608	12123160A	RFF 1.47K 500 MW F+-1%	16299	CGW RN55D 1471 F
R 609	12123000A	RFF 1.0 K 500 MW F+-1%	16299	CGW RN55D 1001 F
R 610	12123880A	RFF 8.25K 500 MW F+-1%	16299	CGW RN55D 8251 F
R 611	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 612	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 613	12122640A	RFF 464.0 500 MW F+-1%	16299	CGW RN55D 4640 F
R 614	12012510A	RFC 100.0 K 1.0 W J+- 5%	01121	A-B TYP GB
R 615	12123320A	RFF 2.15K 500 MW F+-1%	16299	CGW RN55D 2151 F
R 616	12121640A	RFF 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 617	12124320A	RFF 21.5 K 500 MW F+-1%	16299	CGW RN55D 2152 F
R 618	12125280A	RFF 196.0 K 500 MW F+-1%	16299	CGW RN55D 1963 F
R 619	12125160A	RFF 147.0 K 500 MW F+-1%	16299	CGW RN55D 1473 F
R 620	12124640A	RFF 46.4 K 500 MW F+-1%	16299	CGW RN55D 4642 F
R 621	12126000A	RFF 1.00M 500 MW F+-1%	16299	CGW RN55D 1004 F
R 622	12124120A	RFF 13.3 K 500 MW F+-1%	16299	CGW RN55D 1332 F
R 623	12123280A	RFF 1.96K 500 MW F+-1%	16299	CGW RN55D 1961 F
R 624	12123720A	RFF 5.62K 500 MW F+-1%	16299	CGW RN55D 5621 F
R 625	12123560A	RFF 3.83K 500 MW F+-1%	16299	CGW RN55D 3831 F
R 626	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 627	12125160A	RFF 147.0 K 500 MW F+-1%	16299	CGW RN55D 1473 F
R 628	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 629	12123560A	RFF 3.83K 500 MW F+-1%	16299	CGW RN55D 3831 F
R 630	12121560A	RFF 38.3 500 MW F+-1%	16299	CGW RN55D 38R3 F
R 631	09100790A	RVC 100.0 K 0.5 W	50423	
R 632	09100010A	RVC 500.0 0.5 W K	73138	HEL TYP 72PM

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
R 633	12121640A	RFF 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 634	12124080A	RFF 12.1 K 500 MW F+-1%	16299	CGW RN55D 1212 F
R 635	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 636	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 637	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 638	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 639	12121640A	RFF 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 640	12123520A	RFF 3.48K 500 MW F+-1%	16299	CGW RN55D 3481 F
R 641	12121320A	RFF 21.5 500 MW F+-1%	16299	CGW RN55D 21R5 F
R 642	12123520A	RFF 3.48K 500 MW F+-1%	16299	CGW RN55D 3481 F
R 643	09100060A	RVC 1.0 K 0.5 WK +-10%	73138	HEL TYP 72PW
R 644	12123120A	RFF 1.33K 500 MW F+-1%	16299	CGW RN55D 1331 F
R 645	12122800A	RFF 681.0 500 MW F+-1%	16299	CGW RN55D 6810 F
R 646	12123160A	RFF 1.47K 500 MW F+-1%	16299	CGW RN55D 1471 F
R 647	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 648	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 649	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 650	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 651	12123800A	RFF 6.81K 500 MW F+-1%	16299	CGW RN55D 6811 F
R 652	12122880A	RFF 825.0 500 MW F+-1%	16299	CGW RN55D 8250 F
R 653	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 654	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 655	12122800A	RFF 681.0 500 MW F+-1%	16299	CGW RN55D 6810 F
R 656	12122640A	RFF 464.0 500 MW F+-1%	16299	CGW RN55D 4640 F
R 657	12122640A	RFF 464.0 500 MW F+-1%	16299	CGW RN55D 4640 F
R 658	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 659	12124400A	RFF 26.1 K 500 MW F+-1%	16299	CGW RN55D 2612 F
R 660	12121640A	RFF 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 661	12123160A	RFF 1.47K 500 MW F+-1%	16299	CGW RN55D 1471 F
R 662	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 663	12123800A	RFF 6.81K 500 MW F+-1%	16299	CGW RN55D 6811 F
R 664	12122640A	RFF 464.0 500 MW F+-1%	16299	CGW RN55D 4640 F
R 665	12123800A	RFF 6.81K 500 MW F+-1%	16299	CGW RN55D 6811 F
R 666	12123000A	RFF 1.0 K 500 MW F+-1%	16299	CGW RN55D 1001 F
R 667	12121640A	RFF 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 668	12123160A	RFF 1.47K 500 MW F+-1%	16299	CGW RN55D 1471 F
R 669	12123400A	RFF 2.61K 500 MW F+-1%	16299	CGW RN55D 2611 F
R 670	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 671	12123400A	RFF 2.61K 500 MW F+-1%	16299	CGW RN55D 2611 F
R 672	12124160A	RFF 14.7 K 500 MW F+-1%	16299	CGW RN55D 1472 F
R 673	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 674	12122320A	RFF 215.0 500 MW F+-1%	16299	CGW RN55D 2150 F
R 675	12123000A	RFF 1.0 K 500 MW F+-1%	16299	CGW RN55D 1001 F
R 676	12123160A	RFF 1.47K 500 MW F+-1%	16299	CGW RN55D 1471 F
R 677	12121920A	RFF 90.9 500 MW F+-1%	16299	CGW RN55D 90R9 F
R 678	12123080A	RFF 1.21K 500 MW F+-1%	16299	CGW RN55D 1211 F
R 679	12123880A	RFF 8.25K 500 MW F+-1%	16299	CGW RN55D 8251 F
R 680	12123320A	RFF 2.15K 500 MW F+-1%	16299	CGW RN55D 2151 F
R 681	12122800A	RFF 681.0 500 MW F+-1%	16299	CGW RN55D 6810 F
R 682	12122880A	RFF 825.0 500 MW F+-1%	16299	CGW RN55D 8250 F
R 683	12123250A	RFF 1.82K 500 MW F+-1%	16299	CGW RN55D 1821 F
R 684	12123880A	RFF 8.25K 500 MW F+-1%	16299	CGW RN55D 8251 F
R 685	12123160A	RFF 1.47K 500 MW F+-1%	16299	CGW RN55D 1471 F
R 686	12123320A	RFF 2.15K 500 MW F+-1%	16299	CGW RN55D 2151 F
R 687	12123880A	RFF 8.25K 500 MW F+-1%	16299	CGW RN55D 8251 F
R 688	12124320A	RFF 21.5 K 500 MW F+-1%	16299	CGW RN55D 2152 F
R 689	12121640A	RFF 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 690	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 691	12123400A	RFF 2.61K 500 MW F+-1%	16299	CGW RN55D 2611 F
R 692	12124320A	RFF 21.5 K 500 MW F+-1%	16299	CGW RN55D 2152 F

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
R 693	12124320A	RFF 21.5 K 500 MW F+-1%	16299	CGW RN55D 2152 F
R 694	12123320A	RFF 2.15K 500 MW F+-1%	16299	CGW RN55D 2151 F
R 695	09100060A	PVC 1.0 K 0.5 WK +-10%	73138	HEL TYP 72PM
R 696	12123080A	RFF 1.21K 500 MW F+-1%	16299	CGW RN55D 1211 F
R 697	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 698	12122800A	RFF 681.0 500 MW F+-1%	16299	CGW RN55D 6810 F
R 699	12123400A	RFF 2.61K 500 MW F+-1%	16299	CGW RN55D 2611 F
R 700	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 701	12122800A	RFF 681.0 500 MW F+-1%	16299	CGW RN55D 6810 F
R 702	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 703	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 704	12123520A	RFF 3.48K 500 MW F+-1%	16299	CGW RN55D 3481 F
R 705	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 706	12123320A	RFF 2.15K 500 MW F+-1%	16299	CGW RN55D 2151 F
R 707	12123240A	RFF 1.78K 500 MW F+-1%	16299	CGW RN55D 1781 F
R 708	09100610A	PVF 2.0 K 0.5 W +-30%	73138	HEL TYP 72PM
R 709	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 710	12123800A	RFF 6.81K 500 MW F+-1%	16299	CGW RN55D 6811 F
R 711	12060540A	RCF 10.0 M 500.0MW F+- 1%	35929	DDN TYP N4
R 713	12124120A	RFF 13.3 K 500 MW F+-1%	16299	CGW RN55D 1332 F
R 714	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
C 715	09100800A	PVC 22.0 K	50423	
R 716	12123880A	RFF 8.25K 500 MW F+-1%	16299	CGW RN55D 8251 F
R 717	12123560A	RFF 3.83K 500 MW F+-1%	16299	CGW RN55D 3831 F
R 718	12123600A	RFF 4.22K 500 MW F+-1%	16299	CGW RN55D 4221 F
R 719	12123560A	RFF 3.83K 500 MW F+-1%	16299	CGW RN55D 3831 F
R 720	12124000A	RFF 10.0 K 500 MW F+-1%	16299	CGW RN55D 1002 F
R 721	12123800A	RFF 6.81K 500 MW F+-1%	16299	CGW RN55D 6811 F
R 722	12124640A	RFF 46.4 K 500 MW F+-1%	16299	CGW RN55D 4642 F
R 723	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 724	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 725	12123000A	RFF 1.0 K 500 MW F+-1%	16299	CGW RN55D 1001 F
R 726	12122320A	RFF 215.0 500 MW F+-1%	16299	CGW RN55D 2150 F
R 727	12122640A	RFF 464.0 500 MW F+-1%	16299	CGW RN55D 4640 F
R 728	12124000A	RFF 10.0 K 500 MW F+-1%	16299	CGW RN55D 1002 F
C 729	12121000A	RFF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 730	09100010A	PVC 500.0 0.5 W K	73138	HEL TYP 72PM
R 731	12123400A	RFF 2.61K 500 MW F+-1%	16299	CGW RN55D 2611 F
R 732	12122320A	RFF 215.0 500 MW F+-1%	16299	CGW RN55D 2150 F
R 733	12121640A	RFF 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 734	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 735	12123000A	RFF 1.0 K 500 MW F+-1%	16299	CGW RN55D 1001 F
R 736	12122800A	RFF 681.0 500 MW F+-1%	16299	CGW RN55D 6810 F
R 737	12121640A	RFF 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 738	12123560A	RFF 3.83K 500 MW F+-1%	16299	CGW RN55D 3831 F
R 739	12123760A	RFF 6.19K 500 MW F+-1%	16299	CGW RN55D 6191 F
R 740	12122640A	RFF 464.0 500 MW F+-1%	16299	CGW RN55D 4640 F
R 741	12125000A	RFF 100.0 K 500 MW F+-1%	16299	CGW RN55D 1003 F
R 742	12123560A	RFF 3.83K 500 MW F+-1%	16299	CGW RN55D 3831 F
R 743	12123720A	RFF 5.62K 500 MW F+-1%	16299	CGW RN55D 5621 F
R 744	09100740A	RVW 1.0 K 1.0 W	50423	
R 745	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 746	12122640A	RFF 464.0 500 MW F+-1%	16299	CGW RN55D 4640 F
R 756	12122640A	RFF 464.0 500 MW F+-1%	16299	CGW RN55D 4640 F
R 757	12121520A	RFF 34.8 500 MW F+-1%	16299	CGW RN55D 34R8 F
S 50	25100450A	SWC LEVER -4POS 1040A/550	50423	
S 70	25100520A	ICP 15 VOLT REG 78M15C 1/2A	07263	FCHLD 78M15C OR EQUIV
S 71	09100790A	PVC 100.0 K 0.5 W	50423	
S 72	25100460A	SWC LEVER -3POS -1040A/S72	50423	
SKF	31033790A	CON UG-1094/U BNC,DAGE	29587	STATE ELECT.PARTS

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
TR 601	10100010A	TRQ 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 602	10100010A	TRQ 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 603	10100020A	TRQ 2N 930 NPN 1 45 MTO-18	04713	MOT 1.8 30M 40
TR 604	10094730A	TRQ 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
TR 605	10100020A	TRQ 2N 930 NPN 1 45 MTO-18	04713	MOT 1.8 30M 40
TR 606	10094730A	TRQ 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
TR 607	10100541L	TRQ NPN MATCHED PAIR AE-13	50423	
TR 608	10100541L	TRQ NPN MATCHED PAIR AE-13	50423	
TR 609	10079340A	TRQ 2N3640 PNP 1 12 PTO-18	07263	FCH .500 300M 30
TR 610	10079340A	TRQ 2N3640 PNP 1 12 PTO-18	07263	FCH .500 300M 30
TR 611	10100010A	TRQ 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 612	10100010A	TRQ 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 613	10100010A	TRQ 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 614	10100541L	TRQ NPN MATCHED PAIR AE-13	50423	
TR 615	10094730A	TRQ 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
TR 616	10094730A	TRQ 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
TR 617	10100541L	TRQ NPN MATCHED PAIR AE-13	50423	
TR 618	10094730A	TRQ 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
TR 619	10094730A	TRQ 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
TR 620	10100010A	TRQ 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 621	10100010A	TRQ 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 622	10079330A	TRQ 2N4221A FET 1 30 MTO-72	04713	MOT .300 3.5K
TR 623	10100020A	TRQ 2N 930 NPN 1 45 MTO-18	04713	MOT 1.8 30M 40
TR 624	10100020A	TRQ 2N 930 NPN 1 45 MTO-18	04713	MOT 1.8 30M 40
TR 625	10100020A	TRQ 2N 930 NPN 1 45 MTO-18	04713	MOT 1.8 30M 40
TR 626	10094730A	TRQ 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
TR 627	10100020A	TRQ 2N 930 NPN 1 45 MTO-18	04713	MOT 1.8 30M 40
TR 628	10079340A	TRQ 2N3640 PNP 1 12 PTO-18	07263	FCH .500 300M 30
TR 629	10094730A	TRQ 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
TR 630	10100010A	TRQ 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 631	10100010A	TRQ 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 632	10100020A	TRQ 2N 930 NPN 1 45 MTO-18	04713	MOT 1.8 30M 40

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C 901	07095750A	CCD 220 PF 600 V K 10%	71590	CTL TYP DD-721
C 902	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 903	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 904	07023870A	CMM 820 PF 200 V J 5%	56289	SPRAGUE TYPE 192P82152
C 906	07101660A	CYM 10.0NF1600. V 10%TUBUL	09023	CORNELL DUBILIER 16S1
C 907	07250000A	CYM 0.1 UF400.0 VK +-20%	56289	418P10404LA3 RADIAL LEADS
C 908	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 909	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 910	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 911	07101660A	CYM 10.0NF1600. V 10%TUBUL	09023	CORNELL DUBILIER 16S1
C 912	07101550A	CCD 2.2NF 500.0 V 25U+-20%	72982	ERIE 801 Z5U 2.2NF20%500V
C 913	07101660A	CYM 10.0NF1600. V 10%TUBUL	09023	CORNELL DUBILIER 16S1
C 914	07025041A	CCT 2.7PF T	50423	999 STACKPOLE TYPE GA-SPC
D 901	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 902	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 903	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 904	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 905	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 906	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 907	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 908	05100280A	DGP 1N 916 100 10M	04713	MOT SI D07
D 909	05100280A	DGP 1N 916 100 10M	04713	MOT SI D07
D 910	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
L 901	46100000A	FXD FERRITE BEAD	78488	STACKPOLE 57-0180-7D MAT
N 901	16100100A	LMP NEON 105-125V FIRE 135V	74276	SIGNALITE LT2-22-1
N 902	16100100A	LMP NEON 105-125V FIRE 135V	74276	SIGNALITE LT2-22-1
R 903	12124320A	RES 21.5 K 500 MW F+-1%	16299	CGW RN55D 2152 F
R 904	12122640A	RES 464.0 500 MW F+-1%	16299	CGW RN55D 4640 F
R 905	12124640A	RES 46.4 K 500 MW F+-1%	16299	CGW RN55D 4642 F
R 906	12124000A	RES 10.0 K 500 MW F+-1%	16299	CGW RN55D 1002 F
R 907	12124560A	RES 38.3 K 500 MW F+-1%	16299	CGW RN55D 3832 F
R 908	12123320A	RES 2.15K 500 MW F+-1%	16299	CGW RN55D 2151 F
R 909	12123600A	RES 4.22K 500 MW F+-1%	16299	CGW RN55D 4221 F
R 910	12121000A	RES 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 911	12122800A	RES 681.0 500 MW F+-1%	16299	CGW RN55D 6810 F
R 912	12123640A	RES 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 913	12123720A	RES 5.62K 500 MW F+-1%	16299	CGW RN55D 5621 F
R 914	12121640A	RES 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 915	12123920A	RES 9.09K 500 MW F+-1%	16299	CGW RN55D 9091 F
R 916	12122000A	RES 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 917	12123240A	RES 1.78K 500 MW F+-1%	16299	CGW RN55D 1781 F
R 918	12124000A	RES 10.0 K 500 MW F+-1%	16299	CGW RN55D 1002 F
R 919	12124160A	RES 14.7 K 500 MW F+-1%	16299	CGW RN55D 1472 F
R 920	12124880A	RES 82.5 K 500 MW F+-1%	16299	CGW RN55D 8252 F
R 921	12124400A	RES 26.1 K 500 MW F+-1%	16299	CGW RN55D 2612 F
R 922	12121000A	RES 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 923	12124640A	RES 46.4 K 500 MW F+-1%	16299	CGW RN55D 4642 F
R 924	12121000A	RES 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 925	12121000A	RES 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 926	12124000A	RES 10.0 K 500 MW F+-1%	16299	CGW RN55D 1002 F
R 927	12122000A	RES 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 928	12126000A	RES 1.00M 500 MW F+-1%	16299	CGW RN55D 1004 F
R 929	12126000A	RES 1.00M 500 MW F+-1%	16299	CGW RN55D 1004 F
R 930	12011190A	RES 3.3 M 500.0MW J+- 5%	01121	A-B TYP EB
R 931	12011190A	RES 3.3 M 500.0MW J+- 5%	01121	A-B TYP EB
R 932	12011190A	RES 3.3 M 500.0MW J+- 5%	01121	A-B TYP EB
R 933	12011190A	RES 3.3 M 500.0MW J+- 5%	01121	A-B TYP EB
R 934	12124000A	RES 10.0 K 500 MW F+-1%	16299	CGW RN55D 1002 F
R 935	12125000A	RES 100.0 K 500 MW F+-1%	16299	CGW RN55D 1003 F
R 936	12124640A	RES 46.4 K 500 MW F+-1%	16299	CGW RN55D 4642 F
R 937	12125000A	RES 100.0 K 500 MW F+-1%	16299	CGW RN55D 1003 F

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
TR 901	10100020A	TRO 2N 930 NPN 1 45 MTO-18	04713	MCT 1.8 30M 40
TR 902	10100010A	TRO 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 903	10079360A	TRO 2N3053 NPN 1 40 MTO-5	86684	RCA 5 100M 10
TR 904	10100000A	TRO TRANSISTOR FET TYP UC734	21845	SEE 10079330A
		X OUTPUT AMPLIFIER		
C 951	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 952	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 953	07101890A	CSF 560.0PF 500.0 VJ +-5%	71590	CRL TYPE CPR-560J
C 954	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 955	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 956	07200050A	CCD 0.1UF 30.0 VK +-10%	71590	CTL CK-104
C 957	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 958	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 959	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 961	07101630A	CCD 0.1UF 100.0 V GMV	72982	ERIE 7060-100/651-104M
C 963	07078280A	CEA 50 UF 25 V T	73445	ET331X004A5 AMPEREX
C 964	07078280A	CEA 50 UF 25 V T	73445	ET331X004A5 AMPEREX
C 965	07095510A	CCD 10 PF 1 KV K 10%	84171	ARC TYP CCD-100
C 966	07095590A	CCD 150 PF K 10%	84171	ARC TYP CCD-151
D 952	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 953	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 954	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 955	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
L 901	03100020A	CIL .47 UH MOLDED WEEDUCTOR	83125	NYTRONICS DD-0.47 OR EQUV
R 951	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 952	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 953	12123560A	RFF 3.83K 500 MW F+-1%	16299	CGW RN55D 3831 F
R 954	12122520A	RFF 348.0 500 MW F+-1%	16299	CGW RN55D 3480 F
R 955	12121520A	RFF 34.8 500 MW F+-1%	16299	CGW RN55D 34R8 F
R 956	12121520A	RFF 34.8 500 MW F+-1%	16299	CGW RN55D 34R8 F
R 957	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 958	12121640A	RFF 46.4 500 MW F+-1%	16299	CGW RN55D 47R5 F
R 959	12124640A	RFF 46.4 K 500 MW F+-1%	16299	CGW RN55D 4642 F
R 962	12123520A	RFF 3.48K 500 MW F+-1%	16299	CGW RN55D 3481 F
R 963	12123640A	RFF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 964	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 965	12122800A	RFF 681.0 500 MW F+-1%	16299	CGW RN55D 6810 F
R 966	12123160A	RFF 1.47K 500 MW F+-1%	16299	CGW RN55D 1471 F
R 967	12121800A	RFF 68.1 500 MW F+-1%	16299	CGW RN55D 68R1 F
R 968	12123160A	RFF 1.47K 500 MW F+-1%	16299	CGW RN55D 1471 F
R 969	09100040A	RVF 100.0 0.5 W M	73138	HEL TYP 72PM
R 971	12123160A	RFF 1.47K 500 MW F+-1%	16299	CGW RN55D 1471 F
R 972	09100060A	RVC 1.0 K 0.5 WK +-10%	73138	HEL TYP 72PM
R 973	12122640A	RFF 464.0 500 MW F+-1%	16299	CGW RN55D 4640 F
R 974	12122840A	RFF 750.0 500 MW F+-1%	16299	CGW RN55D 7500 F
R 975	12122640A	RFF 464.0 500 MW F+-1%	16299	CGW RN55D 4640 F
R 976	12127540A	RFF 3.9 K 8.0 W J+- 5%	00327	WELWYN E77 ADV-31224
R 979	12127540A	RFF 3.9 K 8.0 W J+- 5%	00327	WELWYN E77 ADV-31224
R 981	12123000A	RFF 1.0 K 500 MW F+-1%	16299	CGW RN55D 1001 F
R 982	12122240A	RFF 178.0 500 MW F+-1%	16299	CGW RN55D 1780 F
R 983	12121800A	RFF 68.1 500 MW F+-1%	16299	CGW RN55D 68R1 F

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
R 984	12122460A	RES 301.0 500 MW F+-1%	16299	CGW RN55D 3010 F
R 985	12123320A	RES 2.15K 500 MW F+-1%	16299	CGW RN55D 2151 F
R 986	12122460A	RES 301.0 500 MW F+-1%	16299	CGW RN55D 3010 F
R 987	12122000A	RES 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 988	12122000A	RES 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 989	12121000A	RES 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 990	12122000A	RES 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 992	12122000A	RES 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 993	12123800A	RES 6.81K 500 MW F+-1%	16299	CGW RN55D 6811 F
TR 951	10100020A	TRQ 2N 930 NPN 1 45 MTO-18	04713	MOT 1.8 30M 4C
TR 952	10094730A	TRQ 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
TR 953	10094730A	TRQ 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
TR 954	10094730A	TRQ 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
TR 955	10094730A	TRQ 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
TR 956	10100160A	TRQ 2N5058 NPN 1 300	07263	FCH 5 1C
TR 957	10100160A	TRQ 2N5058 NPN 1 300	07263	FCH 5 10
TR 958	10100010A	TRQ 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 959	10100010A	TRQ 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 960	10100010A	TRQ 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 961	10100010A	TRQ 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
		POWER SUPPLY		
C 83	07101450A	CEA2C0/200UF250.0 V	56289	62D2538
C 84	07101510A	CEA 5.1MF 40.0 V COMPUTER	90201	MALLORY CGS-512U040R3C3PH
C 85	07101510A	CEA 5.1MF 40.0 V COMPUTER	90201	MALLORY CGS-512U040R3C3PH
C 86	07101450A	CEA2C0/200UF250.0 V	56289	62D2538
C 831	07101410A	CEA 5.0UF 50.0 V MIN/INS	56289	500D5C5G050CB7
C 832	07095790A	CCD 1 NF 150 V K 10%	71590	CTL TYP CE-102
C 833	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 834	07022330A	CMM 3.3NF 500.0 VT	09023	CORNELL-DUBLIER 1R5D33
C 835	07101410A	CEA 5.0UF 50.0 V MIN/INS	56289	500D505G050BB7
C 836	07200050A	CCD 0.1UF 30.0 VK +-10%	71590	CTL CK-104
C 837	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 838	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 839	07200050A	CCD 0.1UF 30.0 VK +-10%	71590	CTL CK-104
D 83	05094910A	DGP 1N4003 200 1A	04713	MOT SI D041
D 84	05094910A	DGP 1N4003 200 1A	04713	MOT SI D041
D 831	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 832	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 833	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 834	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 835	05094910A	DGP 1N4003 200 1A	04713	MOT SI D041
D 836	05094910A	DGP 1N4003 200 1A	04713	MOT SI D041
F 831	19100200A	FUS 0.25A 20 MM SZE 0	75915	LITTELFUSE 211.250
F 832	19100190A	FUS 0.5A 20MM SIZE 0	75915	LITTELFUSE 211.500
F81	19100130A	FUS 1.60A 20MM SZE 0	75915	LITTELFUSE 21101.6
F82	19100130A	FUS 1.60A 20MM SZE 0	75915	LITTELFUSE 21101.6
F83/A	19100180A	FUS 1.00A SLO BLO 20MM SZE 0	75915	LITTELFUSE 213001
F83/B	19100190A	FUS 0.5A 20MM SIZE 0	75915	LITTEFUSE 211.500
IC 801	24094210A	ICP FAIRCHILD UA723C	07263	#U5R7723393
L 831	46100000A	FRB FERRITE BEAD	78488	STACKPOLE 57-0180-7D MAT
L 832	46100000A	FRB FERRITE BEAD	78488	STACKPOLE 57-0180-7D MAT

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
MP 81	05100060A	DGP W04M 400 1.5A	04713	GIC
MR 82	05094910A	DGP 1N4003 200 1A	04713	MOT SI DC41
MR 83	05100060A	DGP W04M 400 1.5A	04713	GIC
N 80	16100080A	LMP INDICATOR, NEON TYPE Q	95263	LEECRAFT 45PN2117
R 83	12124800A	REF 68.1 K 500 MW F+-1%	16299	CGW RN55D 6812 F
R 84	12127580A	REW 47.0 0.5 W J+- 5%	44655	OHMITE 2000 CAT#2862
R 831	12127500A	REC 22.0 1.0 W J+- 5%	01121	A-B TYPE GB
R 832	12122640A	REF 464.0 500 MW F+-1%	16299	CGW RN55D 4640 F
R 833	12122240A	REF 178.0 500 MW F+-1%	16299	CGW RN55D 1780 F
R 834	12123520A	REF 3.48K 500 MW F+-1%	16299	CGW RN55D 3481 F
R 835	12127470A	REW 1.0 8.0 W	44655	OHMITE TYPE 200 CAT#1500
R 836	12127490A	REW .82 6.0 W J	50423	
R 837	12123840A	REF 7.50K 500 MW F+-1%	16299	CGW RN55D 7501 F
R 838	09100060A	RVC 1.0 K 0.5 WK +-10%	73138	HEL TYP 72PM
R 839	12123800A	REF 6.81K 500 MW F+-1%	16299	CGW RN55D 6811 F
R 840	12122880A	REF 825.0 500 MW F+-1%	16299	CGW RN55D 8250 F
R 841	12127510A	REC 2.7 K 1.0 W J+- 5%	01121	A-B TYPE GB
R 842	12124560A	REF 38.3 K 500 MW F+-1%	16299	CGW RN55D 3832 F
R 843	12123520A	REF 3.48K 500 MW F+-1%	16299	CGW RN55D 3481 F
R 844	12123640A	REF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 845	12123000A	REF 1.0 K 500 MW F+-1%	16299	CGW RN55D 1001 F
R 846	12123640A	REF 4.64K 500 MW F+-1%	16299	CGW RN55D 4641 F
R 847	12123840A	REF 7.50K 500 MW F+-1%	16299	CGW RN55D 7501 F
R 848	12123840A	REF 7.50K 500 MW F+-1%	16299	CGW RN55D 7501 F
R 849	12122000A	REF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 850	09100620A	RVC 1.0 K TIME/CM VERN	50423	
R 851	09100660A	RVE 100.0 K .5 W +-10%	73138	HELIPOT 72P TRIMPOT MINI
R 852	12122080A	REF 121.0 500 MW F+-1%	16299	CGW RN55D 1210 F
R 854	09100080A	RVC 10.0 K 0.5 WK +-10%	73138	HEL TYP 72PM
R 855	12123520A	REF 3.48K 500 MW F+-1%	16299	CGW RN55D 3481 F
R 856	12122000A	REF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 857	12122000A	REF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 858	12126000A	REF 1.00M 500 MW F+-1%	16299	CGW RN55D 1004 F
R 859	12121160A	REF 14.7 500 MW F+-1%	16299	CGW RN55D 14R7 F
S 81	25100430A	SWC 1066B ROTARY LINE VOLTS	50423	
T 83	20100150A	TRX POWER 1040A/T83	50423	
TR 831	10100500A	TRQ 2N3905 PNP 1 40 PTO-92	07263	FCH .625 200M 30
TR 832	10100010A	TRQ 2N2369 NPN 1 15 MTO-18	04713	MOT 1.2 500M 20
TR 833	10100020A	TRQ 2N 930 NPN 1 45 MTO-18	04713	MOT 1.8 30M 40
TR 834	10100020A	TRQ 2N 930 NPN 1 45 MTO-18	04713	MOT 1.8 30M 40
TR 835	10100760A	TRQ 2N2905 PNP 1 40 MTO-5	04713	MOT .600 200M 50
TR 836	10100320A	TRQ 2N1613 NPN 1 75 MTO-5	04713	MOT 3 35
TR 837	10100040A	TRQ MJE520 NPN 1 30 P77-03	04713	MOT 25 25
TR 838	10100040A	TRQ MJE520 NPN 1 30 P77-03	04713	MOT 25 25
TR 839	10100490A	TRQ 2N5296 NPN 1 60 PTO220	86684	PCA 36 .8M 30

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C 21	07025060A	CCT 4.7PF T	78488	STACKPOLE TYPE GA-6
C 462	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 463	07025980A	CCT 4.7PF 500 V J+- 5%	95121	QUALITY COMPONENTS TP QC
C 465	07200040A	CCD 27.0PF 500.0 VK +-10%	71590	CTL DB-270
C 654	07095510A	CCD 10 PF 1 KV K 10%	84171	ARC TYP CCD-100
C 801	07101570A	CCD 500.0PF 10.K V +80-20%	91418	RMC SPECIAL H1-K RADIAL
C 802	07101570A	CCD 500.0PF 10.K V +80-20%	91418	RMC SPECIAL H1-K RADIAL
C 803	07101570A	CCD 500.0PF 10.K V +80-20%	91418	RMC SPECIAL H1-K RADIAL
C 804	07200110A	CCD 4.7NF 4.0KVK 10%	91418	HI-KHI-V DISCAP GMV
C 805	07101560A	CCD 2.2NF 2.K V Z5U GMV	72982	ERIE 388P Z5U 2.2NF GMV2K
C 806	07101610A	CCB 500.0PF 12.5KV HV BUTON	71590	CENTRALAB DA245 H1-V0-KAP
C 807	07200110A	CCD 4.7NF 4.0KVK 10%	91418	HI-KHI-V DISCAP GMV
C 808	07101560A	CCD 2.2NF 2.K V Z5U GMV	72982	ERIE 388P Z5U 2.2NF GMV2K
C 809	07101700A	CCD 1.0NF 1.0KV 10%	71590	CENTRALAB DD102
C 812	07101600A	CET 22.0UF 35.0 V SOLIDTAN	90201	MALLORY CSR13F226KL
C 813	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 814	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 815	07078130A	CEA 15.0UF 25.0V T	56289	SPRAGUE 30D156G025CB4
C 816	07095760A	CCD 10 NF 150 V T 40%	71590	CTL TYP DDM 103
C 817	07101270A	CEA 35. UF 16. VT	56289	SPRAGUE 30D356G016CB2
C 818	07023850A	CYF 100 NF 150 V M 20%	72928	GUDEMAN TYPE 338Y104M
D 801	05100120A	DRS HV2.5-12F 12K 2.5M	11961	SEMC SI
D 802	05100120A	DRS HV2.5-12F 12K 2.5M	11961	SEMC SI
D 803	05100120A	DRS HV2.5-12F 12K 2.5M	11961	SEMC SI
D 804	05100120A	DRS HV2.5-12F 12K 2.5M	11961	SEMC SI
D 805	05100120A	DRS HV2.5-12F 12K 2.5M	11961	SEMC SI
D 811	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 812	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 813	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
D 814	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
L 801	03100250A	CIL 150UH +- 5%	76487	MILLEN #34300-150
L 802	03100250A	CIL 150UH +- 5%	76487	MILLEN #34300-150
R 801	12126000A	REF 1.00M 500 MW F+-1%	16299	CGW RN55D 1004 F
R 802	12012770A	REC 1.0 M 1.0 W J+- 5%	01121	A-B TYP GB
R 803	12125560A	REF 383.0 K 500 MW F+-1%	16299	CGW RN55D 3833 F
R 804	12128250A	REC 1.2 M 1.0 W J+- 5%	01121	A-B TYP GB
R 811	12122080A	REF 121.0 500 MW F+-1%	16299	CGW RN55D 1210 F
R 812	12123320A	REF 2.15K 500 MW F+-1%	16299	CGW RN55D 2151 F
R 813	12123000A	REF 1.0 K 500 MW F+-1%	16299	CGW RN55D 1001 F
R 814	12127550A	REW 1.0 3.0 W J	44653	OHMITE SERIES 99 VIT-ENAM
R 815	12123400A	REF 2.61K 500 MW F+-1%	16299	CGW RN55D 2611 F
R 816	12124400A	REF 26.1 K 500 MW F+-1%	16299	CGW RN55D 2612 F
R 817	12124640A	REF 46.4 K 500 MW F+-1%	16299	CGW RN55D 4642 F
R 818	12127520A	REW 390.0 3.0 W J AXL	44653	OHMITE SERIES 99 VIT-ENAH
R 819	12122640A	REF 464.0 500 MW F+-1%	16299	CGW RN55D 4640 F
R 820	12122640A	REF 464.0 500 MW F+-1%	16299	CGW RN55D 4640 F
R 822	12121000A	REF 10.0 500 MW F+-1%	16299	CGW RN55D 10R0 F
R 823	12123000A	REF 1.0 K 500 MW F+-1%	16299	CGW RN55D 1001 F
R 824	12124720A	REF 56.2 K 500 MW F+-1%	16299	CGW RN55D 5622 F
R 825	12125320A	REF 215.0 K 500 MW F+-1%	16299	CGW RN55D 2153 F
S 74	09100770A	RVC 10.0 K 0.5 W	50423	
T 801	20100140A	TRX HIGH VOLT-1040A/T801	50423	
TP 600	48100010A	SOC TEFLON FOTHRU TEST PT.	98291	011-2049/GOLD PLATE
TP 811	10100000A	TRQ TRANSISTOR FET TYP UC734	21845	SEE 10079330A
TP 812	10079360A	TRQ 2N3053 NPN 1 40 MTC-5	86684	RCA 5 100M 10
TP 813	10100040A	TRQ MJE520 NPN 1 30 P77-03	04713	MOT 25 25
TP 814	10100520A	TRQ 2N3053A NPN 1 50 MTO-5	86684	RCA 1 100M 50
TP 815	10100520A	TRQ 2N3053A NPN 1 50 MTO-5	86684	RCA 1 100M 50
TP 816	10100500A	TRQ 2N3905 PNP 1 40 PTO-92	07263	FCH .625 200M 30

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C 456	07022960A	CMD 68.0PF 500.0 VJ	84171	ARCO DM-15-680J
C 457	07250040A	CYM 1.0 UF160.0 VF +-1%	84171	ARCO DM10-010D
C 458	07250050A	CYM 0.1 UF160.0 VF +-1%	84171	ARCO 2MPD104J
C 459	07250060A	CYM 0.01UF160.0 VF +-1%	84171	ARCO DM30-103F
C 460	07250070A	CYM 900.0 PF160.0 VF +-1%	84171	ARCO DM15-911F
C 461	07095520A	CCD 100 PF 1 KV K 10%	84171	ARC TYP CCD-101
C 649	07250040A	CYM 1.0 UF160.0 VF +-1%	84171	ARCO DM10-010D
C 650	07250050A	CYM 0.1 UF160.0 VF +-1%	84171	ARCO 2MPD104J
C 651	07250060A	CYM 0.01UF160.0 VF +-1%	84171	ARCO DM30-103F
C 652	07250070A	CYM 900.0 PF160.0 VF +-1%	84171	ARCO DM15-911F
C 653	07022960A	CMD 68.0PF 500.0 VJ	84171	ARCO DM-15-680J
ILP 83	16100090A	LMP SCBASE 14V, .56W	50423	
ILP 84	16100090A	LMP SCBASE 14V, .56W	50423	
L 83	03100260A	CIL CRT TWIST-ALIGN1040A/L83	50423	
R 28	12122000A	REF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 29	12122000A	REF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 30	12122000A	REF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 31	12122000A	REF 100.0 500 MW F+-1%	16299	CGW RN55D 1000 F
R 60	09100700A	RVC 4.7 K 0.5 W	50423	
R 80	09100680A	RVC 470.0 K 0.5 W R80	50423	
R 81	09100710A	RVC 100.0 K 0.5 W R81	50423	
R 82	09100690A	RVC 4.7 K 0.5 W R82	50423	
R 507	09100770A	RVC 10.0 K 0.5 W	50423	
R 561	12014730A	RCF 10.0 M 1.0 W F+- 1%	63060	VIC TYP F X2
R 562	12150050A	REF 4.99M 1.0 W F+- 1%	35929	CONSTANTA CO LTD N3
R 563	12150040A	REF 3.01M 1.0 W F+- 1%	35929	CONSTANTA CO LTD N3
R 564	12126000A	REF 1.00M 500 MW F+-1%	16299	CGW RN55D 1004 F
R 565	12125670A	REF 499.0 K 500 MW F+-1%	16299	CGW RN55D 4993 F
R 566	12125460A	REF 301.0 K 500 MW F+-1%	16299	CGW RN55D 3013 F
R 567	12125000A	REF 100.0 K 500 MW F+-1%	16299	CGW RN55D 1003 F
R 568	12124670A	REF 49.9 K 500 MW F+-1%	16299	CGW RN55D 4992 F
R 569	12124460A	REF 30.1 K 500 MW F+-1%	16299	CGW RN55D 3092 F
R 570	12124290A	REF 20.0 K 500 MW F+-1%	16299	CGW RN55D 2002 F
R 712	09100760A	RVC 10.0 K 0.5 W R712	50423	
R 747	12150050A	REF 4.99M 1.0 W F+- 1%	35929	CONSTANTA CO LTD N3
R 748	12150040A	REF 3.01M 1.0 W F+- 1%	35929	CONSTANTA CO LTD N3
R 749	12126000A	REF 1.00M 500 MW F+-1%	16299	CGW RN55D 1004 F
R 750	12125670A	REF 499.0 K 500 MW F+-1%	16299	CGW RN55D 4993 F
R 751	12125460A	REF 301.0 K 500 MW F+-1%	16299	CGW RN55D 3013 F
R 752	12125000A	REF 100.0 K 500 MW F+-1%	16299	CGW RN55D 1003 F
R 753	12124670A	REF 49.9 K 500 MW F+-1%	16299	CGW RN55D 4992 F
R 754	12124460A	REF 30.1 K 500 MW F+-1%	16299	CGW RN55D 3092 F
R 755	12124290A	REF 20.0 K 500 MW F+-1%	16299	CGW RN55D 2002 F
S 12	09100730A	RVC 250.0 0.5 W R26	50423	
S 22	09100730A	RVC 250.0 0.5 W R26	50423	
S 31	25100470A	SWC ROTARY 1040A/S31	50423	
S 43	25100500A	SWC ROTARY 1040A/S43	50423	
S 73	09100490A	RVC 20.0 K PC CERMET TRMPOT	32997	BOURNS 3059P
S 201	25100420A	SWC 1066B SWC.SLIDE DP/DT	50423	ADVANCE PA/4069
SKD	48100000A	SOC BNC 50 OHMS UG 1094/U	50423	SEE 31033790A
SKG	48100020A	SOC 4MM BLK BANANA JACK	83330	HH.SMITH #1498-103 (BLK)
SKH	48100020A	SOC 4MM BLK BANANA JACK	83330	HH.SMITH #1498-103 (BLK)
SKJ	48100020A	SOC 4MM BLK BANANA JACK	83330	HH.SMITH #1498-103 (BLK)
SKL	48100020A	SOC 4MM BLK BANANA JACK	83330	HH.SMITH #1498-103 (BLK)
SKP	48100000A	SOC BNC 50 OHMS UG 1094/U	50423	SEE 31033790A
SKY	48100000A	SOC BNC 50 OHMS UG 1094/U	50423	SEE 31033790A
V 83	21100140A	TBE CRT 10KV 8X10 INTGRAT P7	73445	AMPEREX D14-121GMP7INTCRT
—	33100000A	LNC LINE CORD SET 7FT MLD	70903	BELDEN CORD SET BN772

SUBASSEMBLY P/N 89102741A

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C 1001	07102400A	CVA 25.0PF	50423	JKSCN 5103/25 DUAL TUNING
C 1002	07095740A	CCD 1.5NF 1.0KV +-10%	71590	CTL TYP DD-152
C 1003	07022860A	CMD 39 PF 500 V J 5%	84171	ARCO TYPE DM-15-390-J
C 1004	07022850A	CMD 20 PF 500 V J 5%	84171	ARCO TYPE DM-15-200-J
C 1005	07024460A	CVC005.5-18PF 350 V	72982	ERIE 538-C02 NOP
C 1006	07091510A	CVC C08.0-50PF 350 V	72982	ERIE557-091 N750 U2P0 34P
J 1001	31100700A	JAK TIP JACK RED	74970	EF.JOHNSON 105-0602-001
J 1002	31100700A	JAK TIP JACK RED	74970	EF.JOHNSON 105-0602-001
J 1003	31100710A	JAK TIP JACK BLK	74970	EF JOHNSON 105-0603-001
J 1004	31033790A	CON UG-1094/U BNC,DAGE	29587	STATE ELECT.PARTS
L 1001	46100000A	FRB FERRITE BEAD	78488	STACKPOLE 57-0180-7D MAT
L 1002	46100000A	FRB FERRITE BEAD	78488	STACKPOLE 57-0180-7D MAT
L 1003	46100000A	FRB FERRITE BEAD	78488	STACKPOLE 57-0180-7D MAT
L 1004	46100000A	FRB FERRITE BEAD	78488	STACKPOLE 57-0180-7D MAT
L 1005	03100391A	CIL 1040A MOD.49 RF XFORMER	50423	BLI TANK
L 1006	03100391A	CIL 1040A MOD.49 RF XFORMER	50423	BLI TANK
L 1007	03100381A	CIL 1040A MOD.49 RF XFORMER	50423	BLI HAIRPIN FEED
R 1001	12125680A	REF 511.0 K 500 MW F+-1%	16299	CGW RN55D 5113 F
R 1002	12125680A	REF 511.0 K 500 MW F+-1%	16299	CGW RN55D 5113 F
R 1003	12127590A	REC 10.0 K 1.0 W J+- 5%	01121	A-B 1 WATT CARBON
R 1004	12127590A	REC 10.0 K 1.0 W J+- 5%	01121	A-B 1 WATT CARBON
S 1001	25077710A	SWC SLIDE, 2PDT	78488	STACKPOLE SS50
S 1002	25100560A	SWC SLIDE DP4T 1066BM0D49	79727	CONT.WIRT 5295F

SUBASSEMBLY P/N 89102821A

L 1010	03062850A	CIL 220 UH	76493	MILLER #9210-92
L 1011	03062850A	CIL 220 UH	76493	MILLER #9210-92
R 1005	12123840A	REF 7.50K 500 MW F+-1%	16299	CGW RN55D 7501 F
R 1006	12123840A	REF 7.50K 500 MW F+-1%	16299	CGW RN55D 7501 F

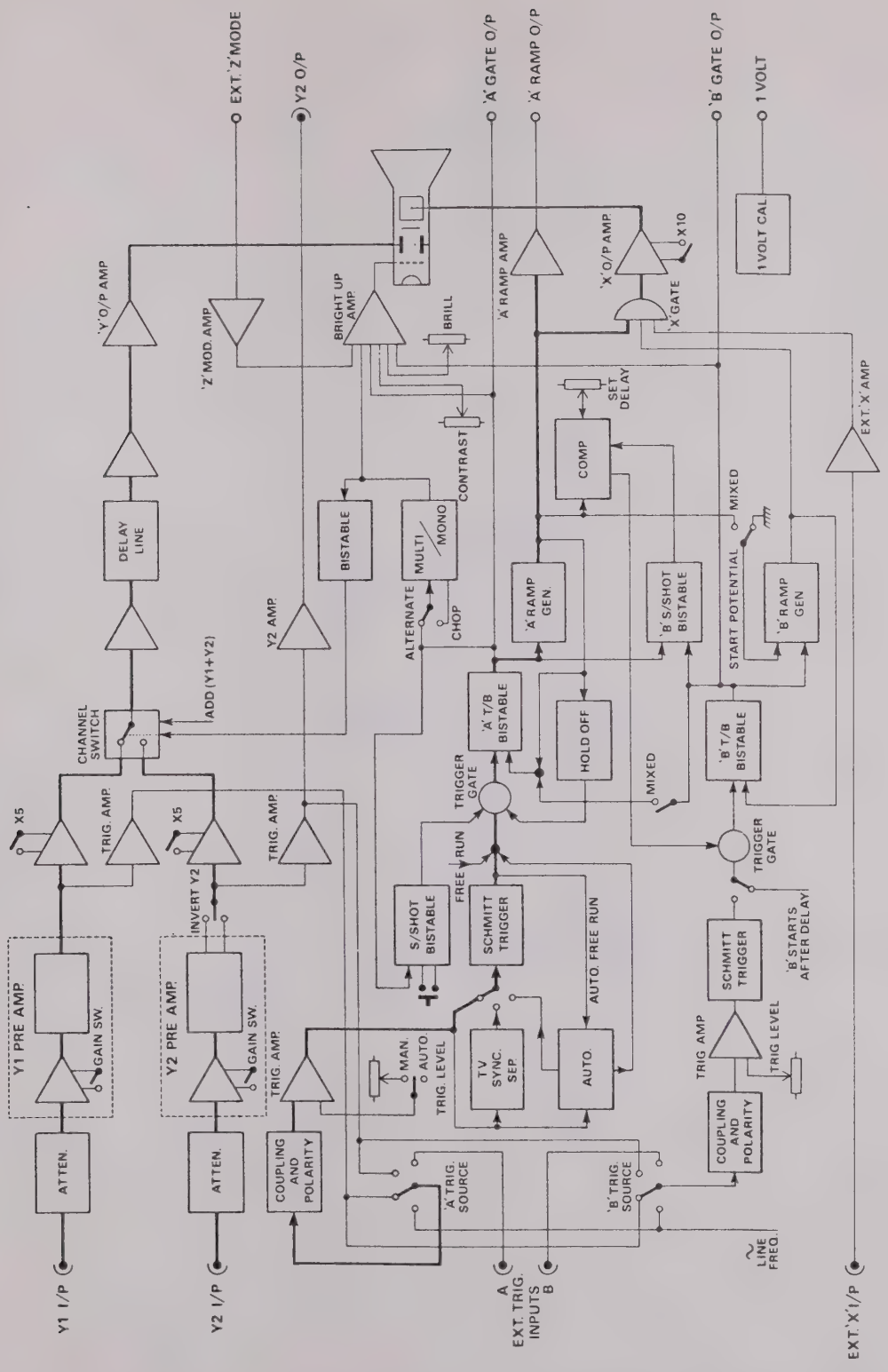
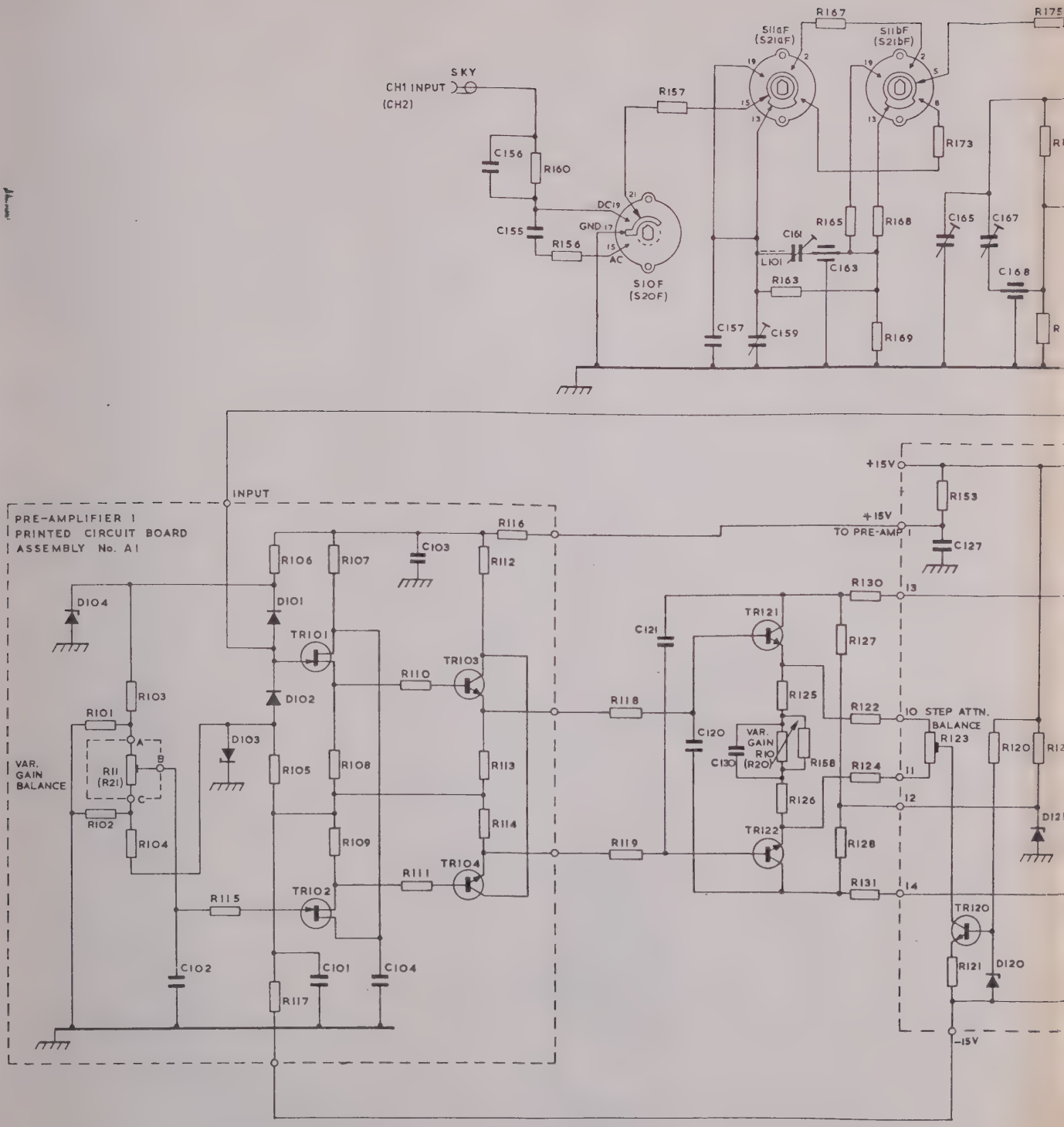
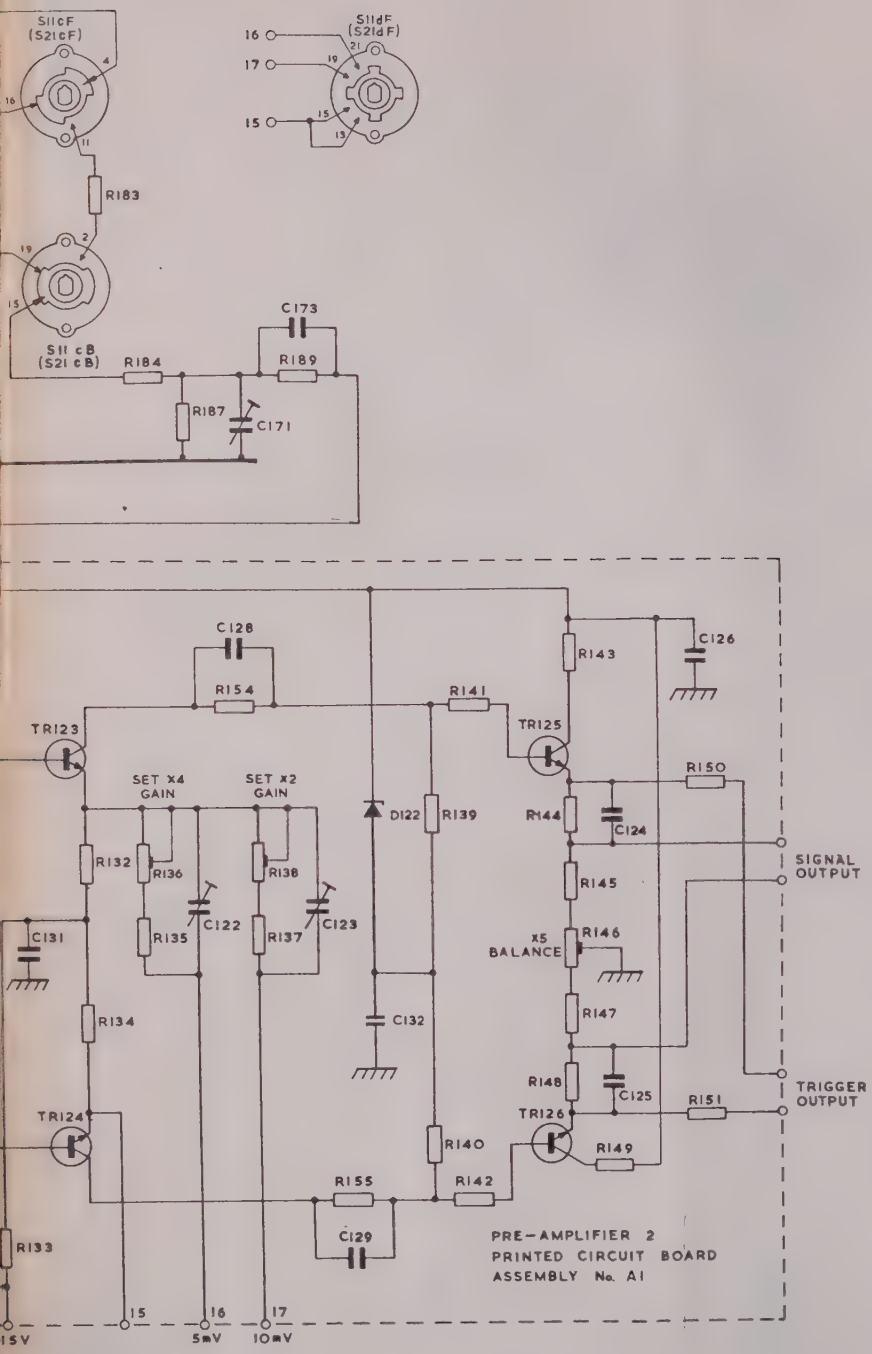


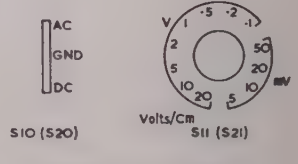
Figure 1. Block Diagram


SKY
CH1 INPUT
(CH2)
C156
R160
C155
R156
S10F
(S20F)
R157
S11aF
(S21aF)
S11bF
(S21bF)
R167
R175
R173
R165
R168
C161
L101
C163
R163
C157
C159
R169
C165
C167
C168
INPUT
PRE-AMPLIFIER 1
PRINTED CIRCUIT BOARD
ASSEMBLY No. A1
R106
R107
C103
R116
R112
D104
D101
TR101
TR103
R110
D102
R103
R101
D103
R105
R108
R113
R114
R109
R104
R102
R111
TR104
TR102
R115
C102
C101
C104
R117
VAR.
GAIN
BALANCE
R11
(R21)
A
B
C
R118
R119
C121
C120
C130
VAR.
GAIN
R10
(R20)
R158
TR121
TR122
R130
R127
R125
R122
R124
R126
R128
R131
10 STEP ATTN.
BALANCE
R123
R120
TR120
R121
D120
+15V
R153
+15V
TO PRE-AMP 1
C127
-15V



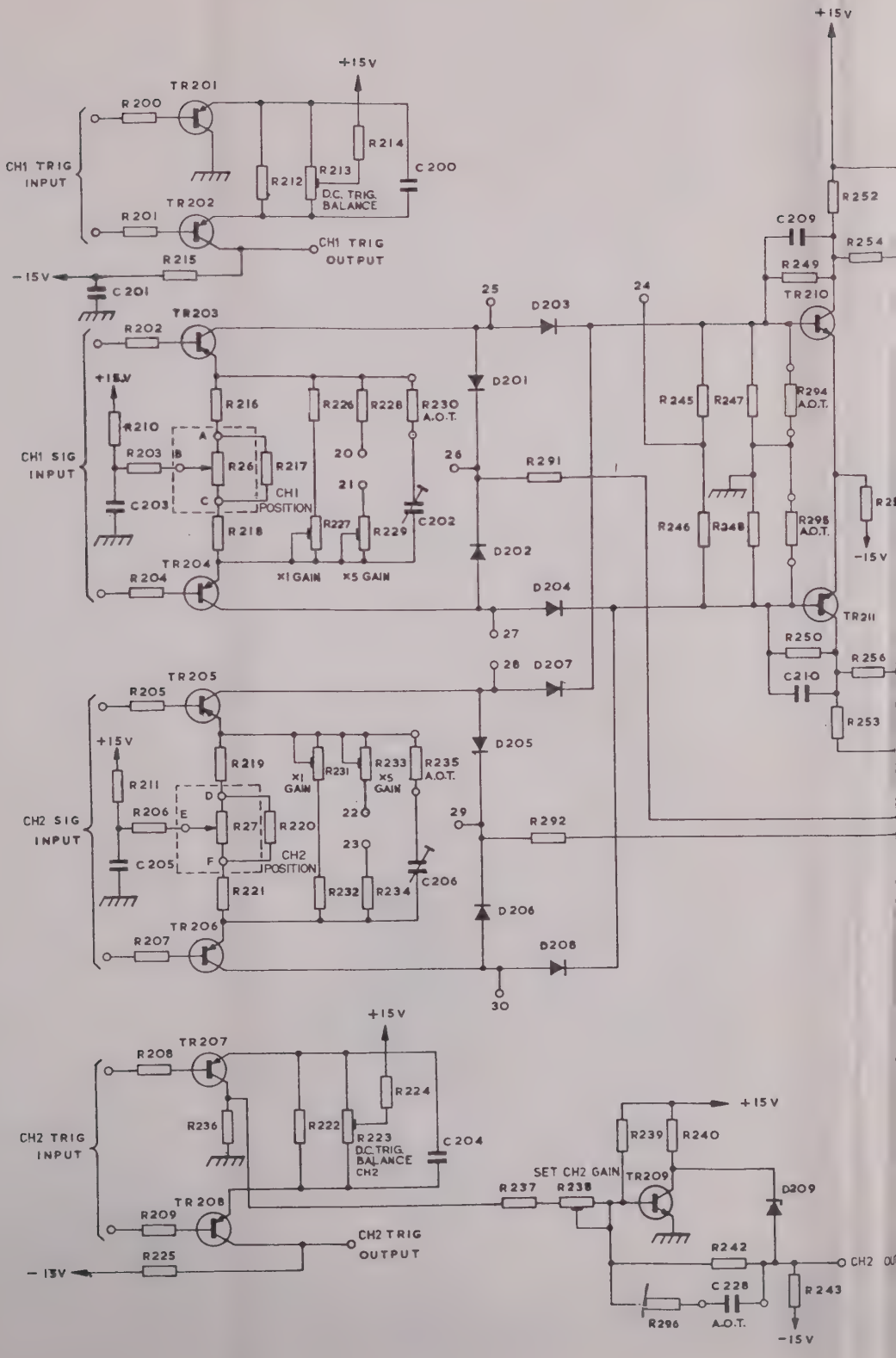
NOTE:

SYMBOLS IN BRACKETS ( ) REFER TO CH2 PRE-AMPLIFIER 2.



FRONT PANEL MARKING

Figure 2. Pre-Amp 1 and 2 and Gain Switching


+15V
TR201
R200
CH1 TRIG INPUT
R214
R212
R213
C200
D.C. TRIG. BALANCE
TR202
R201
CH1 TRIG OUTPUT
R215
-15V
C201
TR203
R202
25
D203
24
D201
+15V
R216
R226
R228
R230 A.O.T.
R210
A
R203
B
R26
R217
20
26
R291
CH1 SIG INPUT
21
CH1 POSITION
C
C203
C202
R218
R227
R229
D202
TR204
R204
×1 GAIN
×5 GAIN
D204
27
TR205
R205
28
D207
D205
+15V
R219
×1 GAIN
R231
R233
×5 GAIN
R235 A.O.T.
R211
D
R206
E
R27
R220
22
29
R292
CH2 SIG INPUT
23
CH2 POSITION
C205
F
C206
R221
R232
R234
D206
TR206
R207
D208
30
+15V
TR207
R208
R224
R236
R222
R223 D.C. TRIG. BALANCE CH2
C204
CH2 TRIG INPUT
TR208
R209
CH2 TRIG OUTPUT
R225
-15V
+15V
R239
R240
SET CH2 GAIN
R237
R238
TR209
D209
R242
CH2 OUT
C228
R243
R296
A.O.T.
-15V
+15V
R252
C209
R254
R249
TR210
R245
R247
R294 A.O.T.
R246
R248
R295 A.O.T.
-15V
TR211
R250
R256
C210
R253

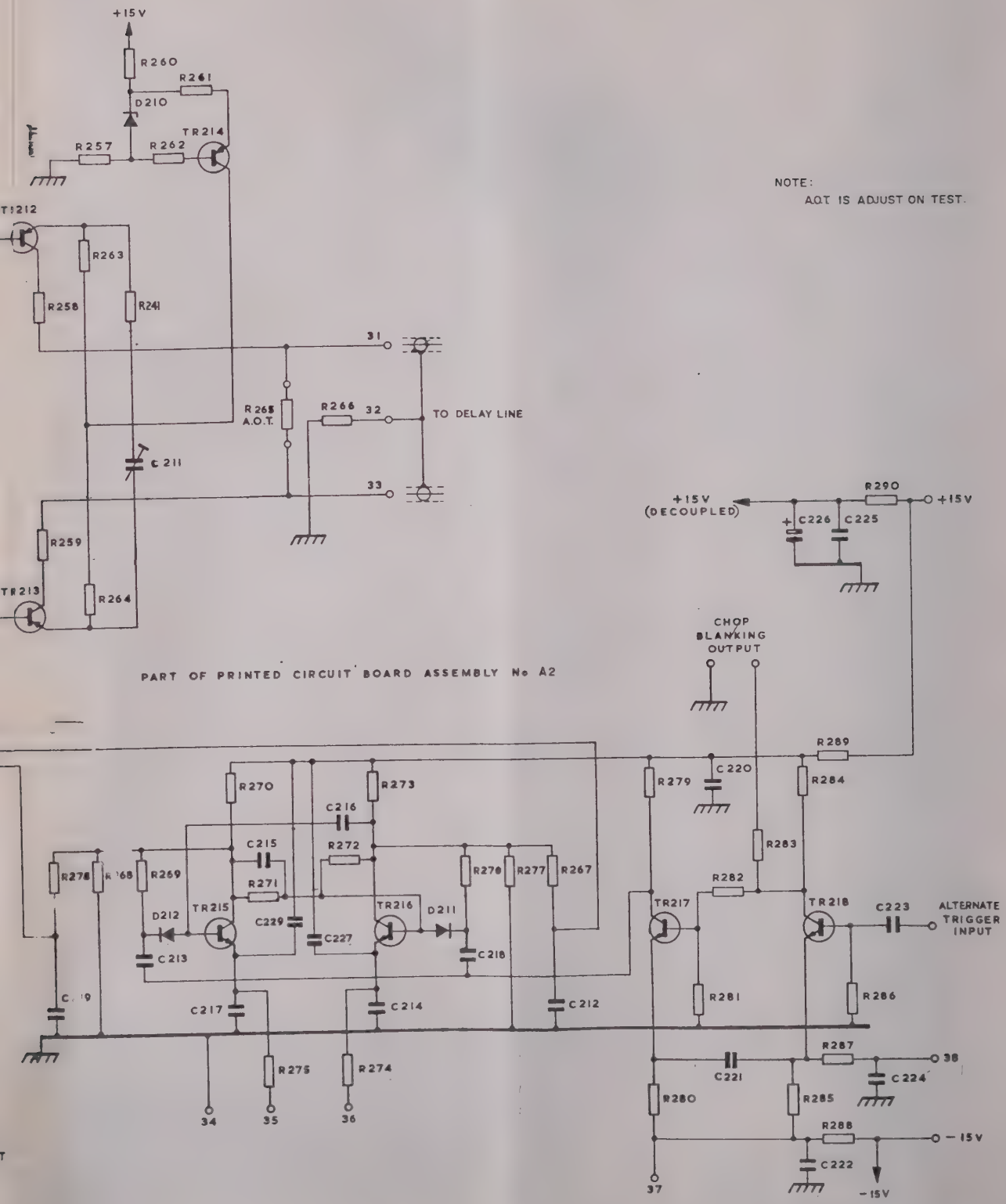
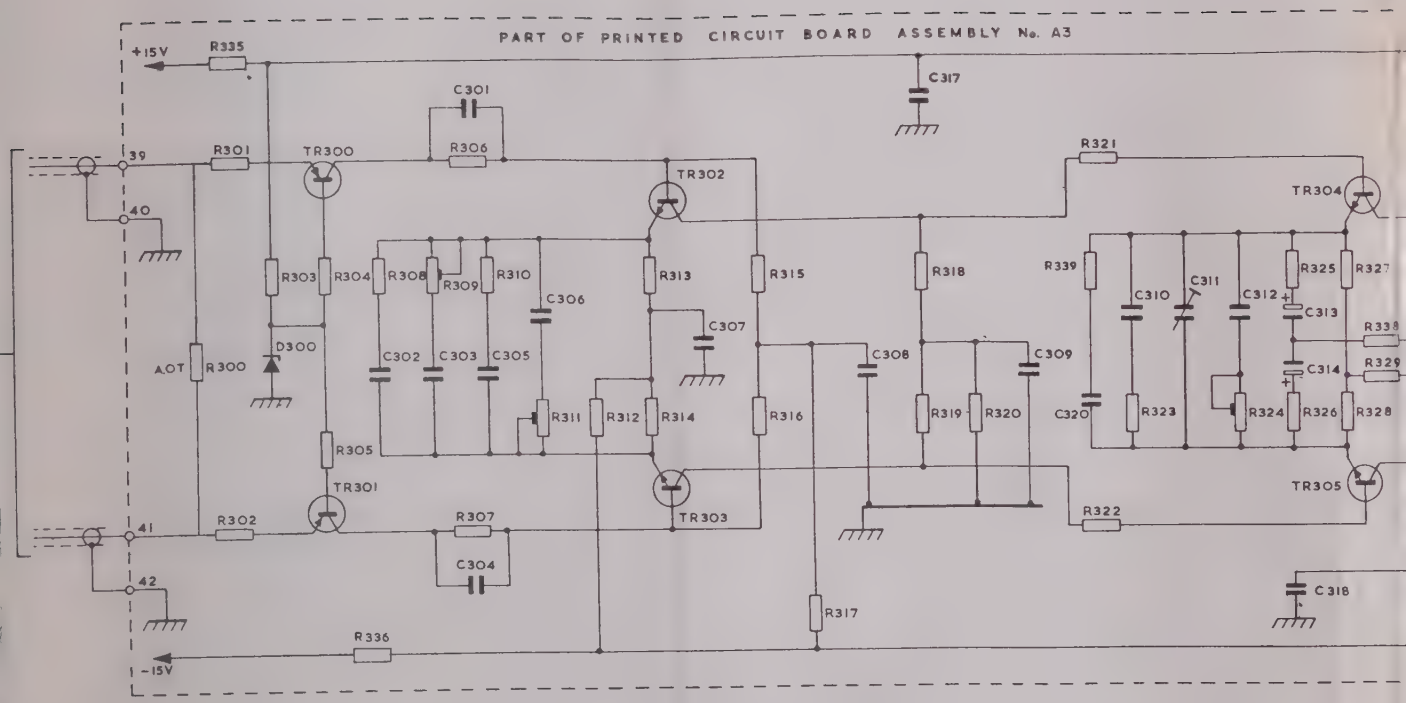


Figure 3. Delay Line Driver and Beam Switch


PART OF PRINTED CIRCUIT BOARD ASSEMBLY No. A3
+15V
R335
C301
C317
39
R301
TR300
R306
TR302
R321
TR304
40
R303
R304
R308
R309
R310
C306
R313
R315
R318
R339
C310
C311
C312
R325
R327
C313
R338
AOT
R300
D300
C302
C303
C305
C307
C308
C309
C314
R329
R311
R312
R314
R316
R319
R320
C320
R323
R324
R326
R328
R305
TR301
TR303
TR305
41
R302
R307
R322
C304
42
C318
R317
R336
-15V

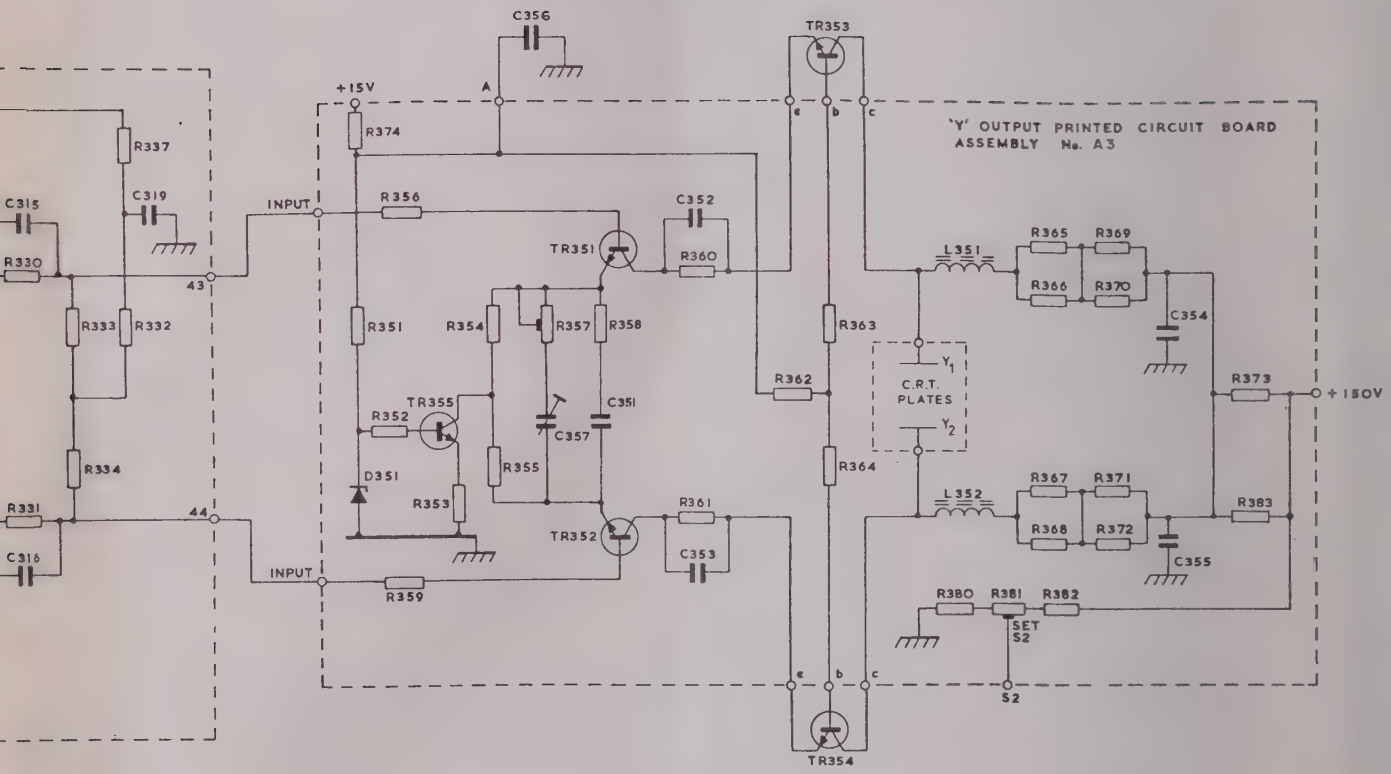
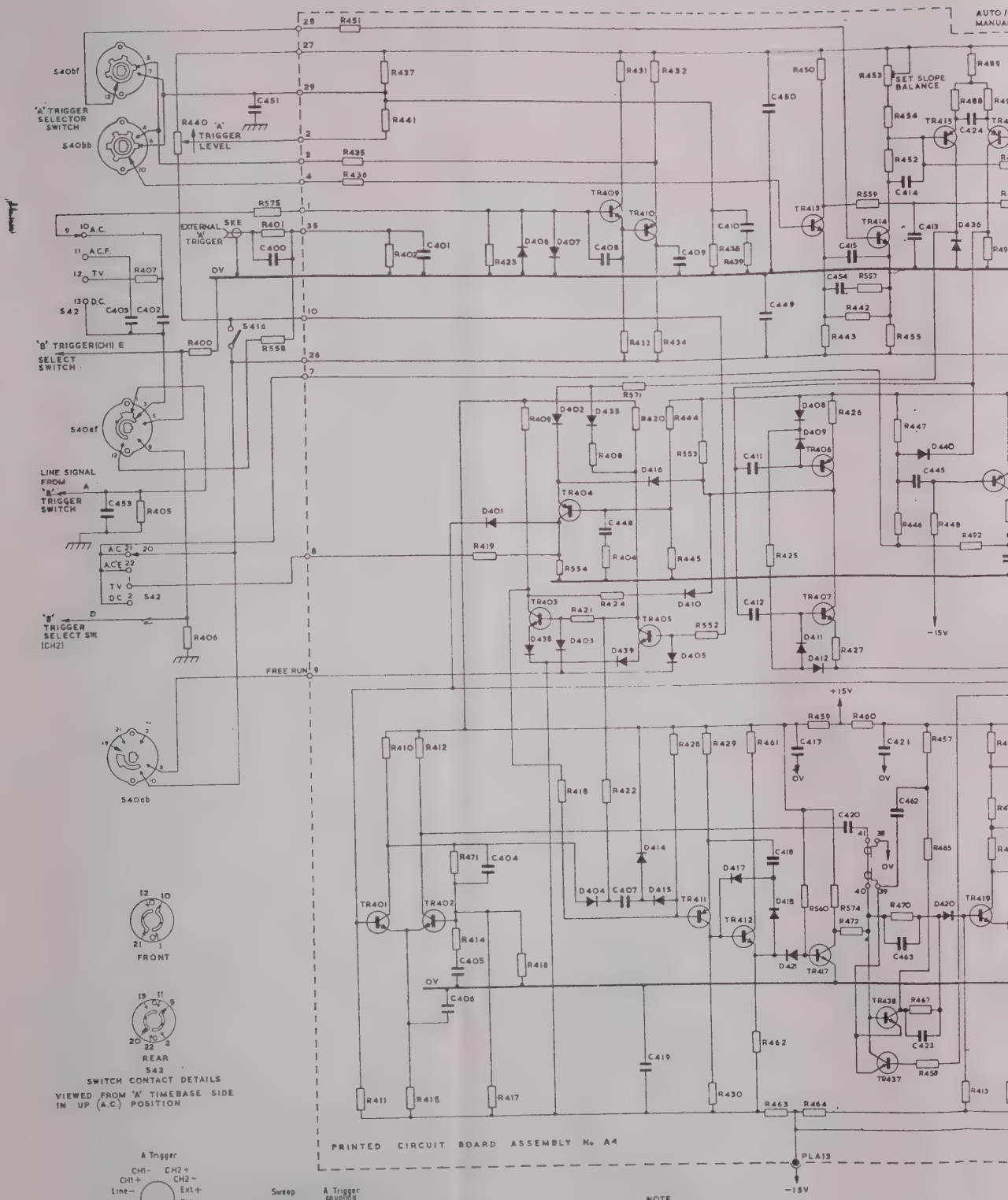


Figure 4. Delay Equalizer and Output Driver


S40bf
'A' TRIGGER SELECTOR SWITCH
S40bb
R440 'A' TRIGGER LEVEL
C451
R451
R437
R441
R435
R436
R575
EXTERNAL TRIGGER
SKE
R401
C400
C401
R402
R423
D406
D407
C408
C409
R438
R439
TR409
TR410
C410
R450
C450
R453
SET SLOPE BALANCE
R454
R452
C414
TR413
TR414
R559
C413
D436
C415
C454
R557
C449
R442
R443
R455
R433
R434
A.C.
A.C.F.
TV
D.C.
S42
C403
C402
R407
'B' TRIGGER(CH1) E SELECT SWITCH
R400
S41a
R558
0V
S40af
LINE SIGNAL FROM 'B' TRIGGER SWITCH
C453
R405
A.C.
A.C.F.
TV
D.C.
S42
'B' TRIGGER SELECT SW. (CH2)
R406
FREE RUN
S40ab
R571
R409
D402
D435
R420
R444
R408
D416
R553
TR404
D401
C448
R419
R554
R404
R445
TR403
R421
R424
D410
D438
D403
D439
TR405
R552
D405
D408
R426
D409
TR406
C411
R425
R447
D440
C445
R446
R448
R492
C412
TR407
D411
D412
R427
-15V
+15V
R459
R460
R410
R412
R428
R429
R461
C417
C421
R457
R418
R422
C462
C420
R465
R471
C404
D414
C418
D417
D404
C407
D415
TR411
D418
R560
R574
R470
D420
TR419
TR401
TR402
R472
TR412
C463
R414
C405
R416
D421
TR417
0V
C406
TR438
R467
C423
R462
C419
TR437
R458
R411
R415
R417
R430
R463
R464
R413
PRINTED CIRCUIT BOARD ASSEMBLY No A4
PLA13
-15V
FRONT
REAR
S42
SWITCH CONTACT DETAILS
VIEWED FROM 'A' TIMEBASE SIDE IN UP (A.C.) POSITION
A Trigger
CH1-
CH2+
CH1+
CH2-
Line-
Ext+
Line+
Ext-
Free run
S40
FRONT PANEL MARKING
Sweep
Normal
Single sweep
Arm
S44
A Trigger coupling
AC
ACF
TVF
DC
S42
FRONT PANEL MARKINGS
NOTE
INDICATES P.C.B. EDGE CONNECTIONS
INDICATES P.C.B CONNECTION PINS

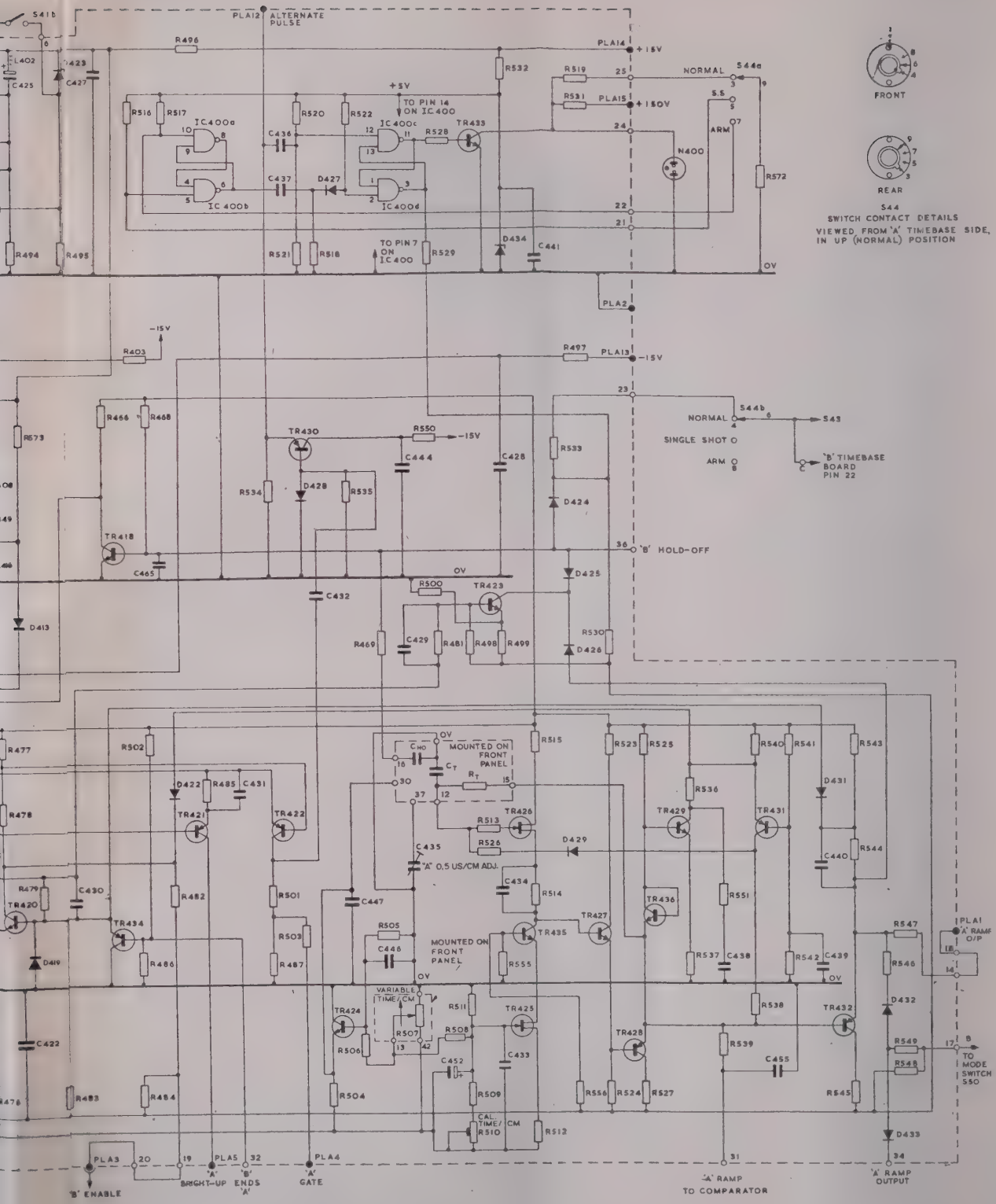
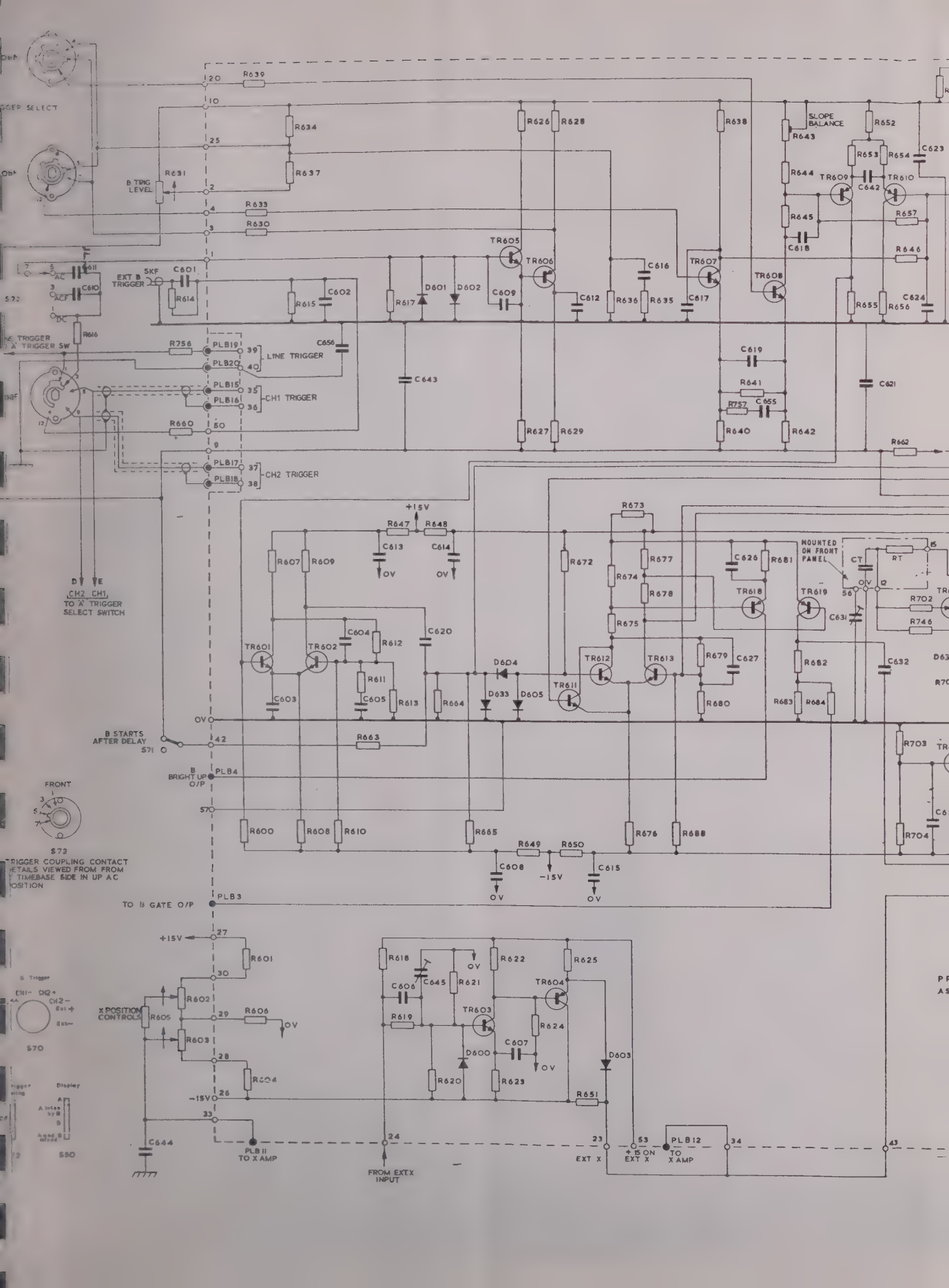


Figure 5. A Timebase


R639
R634
R637
R631
B TRIG LEVEL
R633
R630
R626
R628
R638
SLOPE BALANCE
R643
R652
R653
R654
C623
R644
TR609
TR610
C642
R645
R657
C618
R646
TR605
TR606
TR607
TR608
C616
C612
R636
R635
C617
R655
R656
C624
EXT B TRIGGER
5KF
C601
R614
C602
R615
R617
D601
D602
C609
C610
C611
R616
S72
R756
PLB19
PLB20
LINE TRIGGER
C656
PLB15
PLB16
CH1 TRIGGER
R660
PLB17
PLB18
CH2 TRIGGER
C643
C619
R641
R757
C655
R640
R642
R627
R629
C621
R662
+15V
R647
R648
C613
C614
R607
R609
R672
R673
R677
R674
R678
R675
C626
R681
MOUNTED ON FRONT PANEL
CT
RT
R702
R746
TR618
TR619
C631
TR601
TR602
C604
R612
C620
R611
C603
C605
R613
R664
D604
D633
D605
TR611
TR612
TR613
R679
C627
R680
R682
C632
R683
R684
D63
R70
0V
B STARTS AFTER DELAY
S71
R663
B BRIGHT UP O/P
PLB4
S70
R600
R608
R610
R665
R649
R650
C608
-15V
C615
R676
R688
R703
R704
TO B GATE O/P
PLB3
FRONT
S72
TRIGGER COUPLING CONTACT DETAILS VIEWED FROM FROM TIMEBASE SIDE IN UP AC POSITION
CH2 CH1 TO A TRIGGER SELECT SWITCH
+15V
R601
R602
R605
R603
R606
R604
-15V
C644
X POSITION CONTROLS
PLB 11 TO X AMP
R618
C645
R621
R622
R625
C606
TR604
R619
TR603
R624
C607
D600
R620
R623
D603
R651
FROM EXT X INPUT
EXT X
+15 ON EXT X
PLB 12 TO X AMP

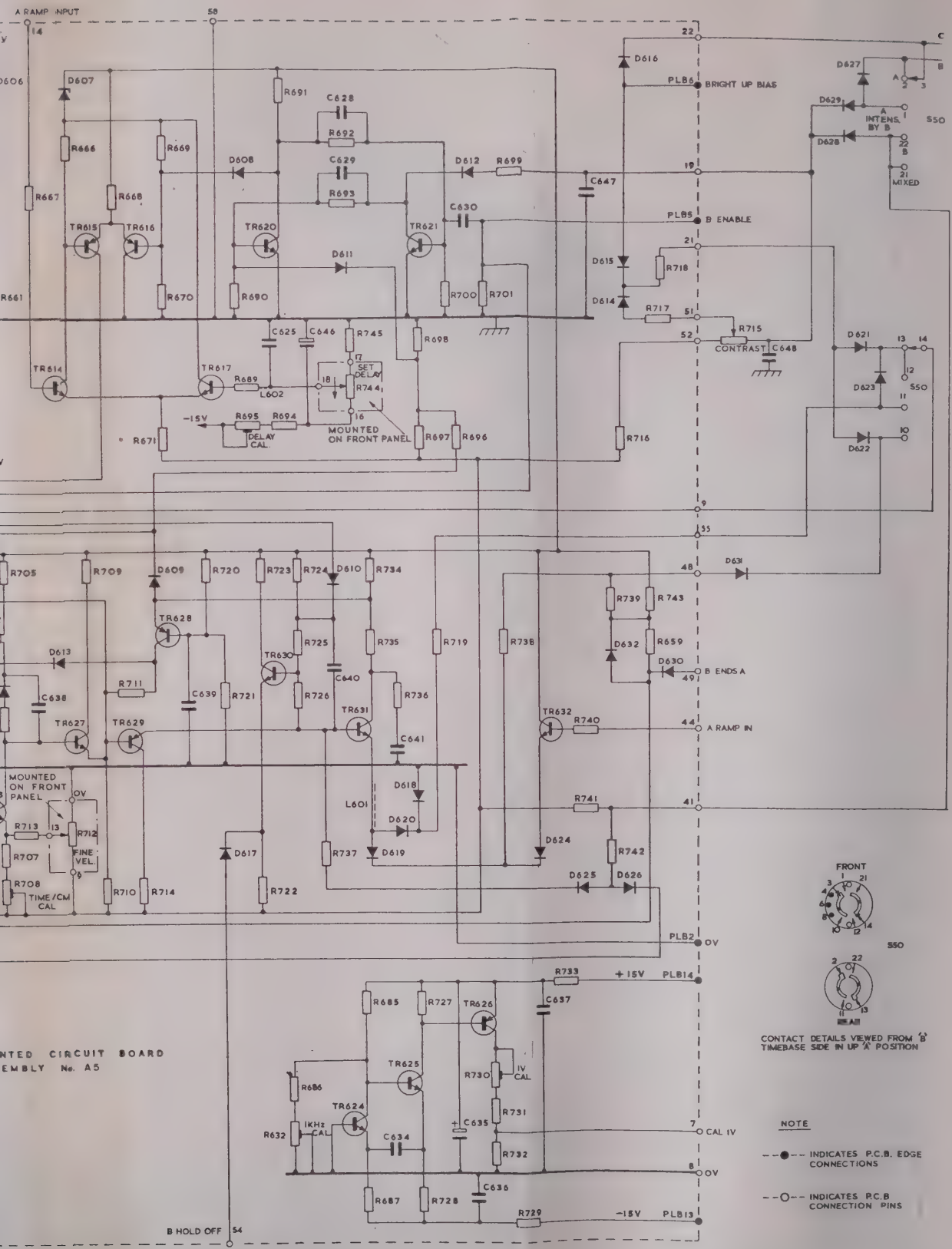
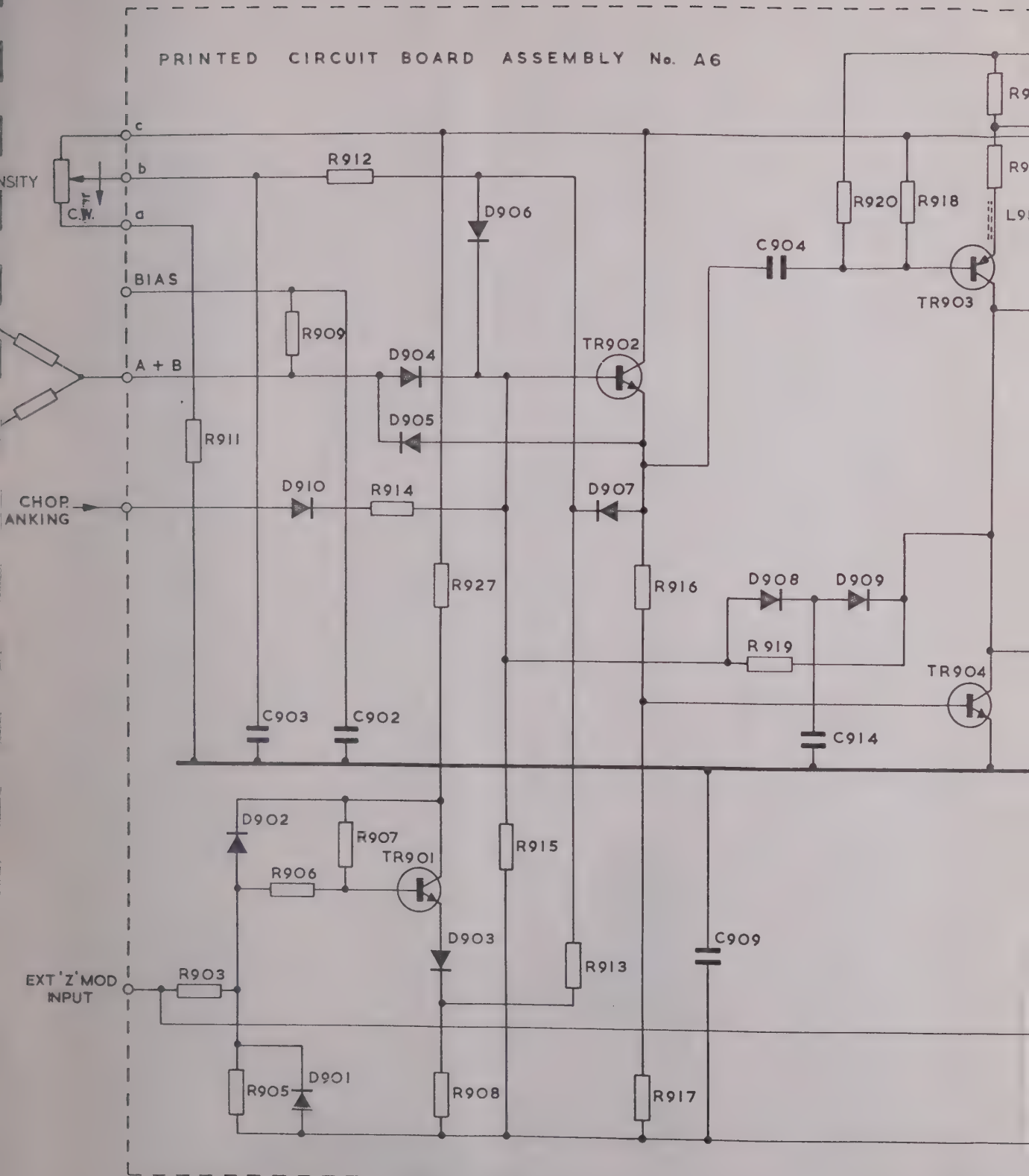


Figure 6. B Timebase


PRINTED CIRCUIT BOARD ASSEMBLY No. A6
NSITY
C.W.
c
b
a
BIAS
A + B
CHOP.
ANKING
EXT 'Z' MOD
INPUT
R912
D906
R909
D904
D905
R911
D910
R914
D907
R927
R916
D908
D909
R919
TR902
TR903
TR904
R920
R918
C904
C903
C902
C914
D902
R907
TR901
R906
R915
D903
R913
C909
R903
R905
D901
R908
R917

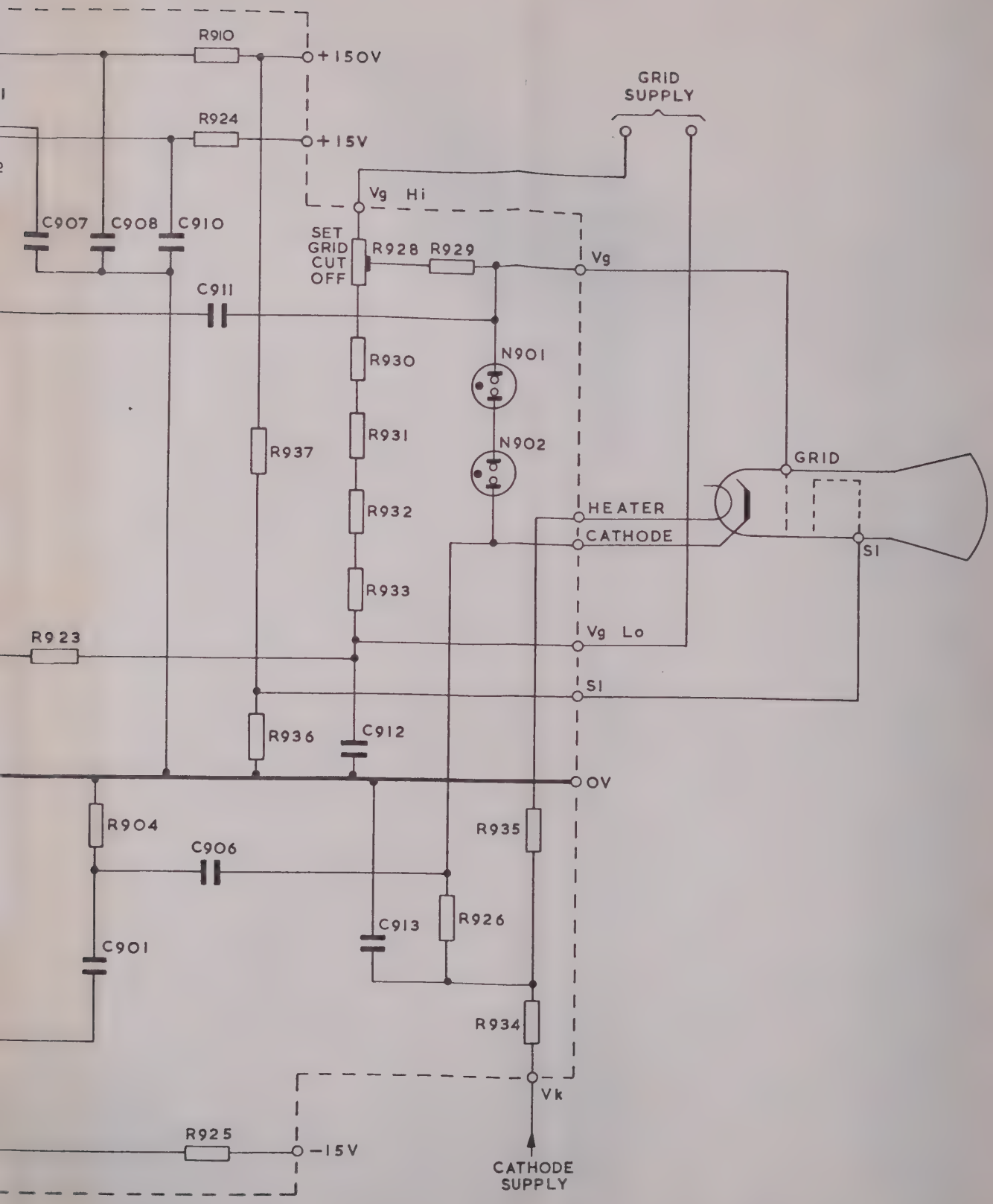
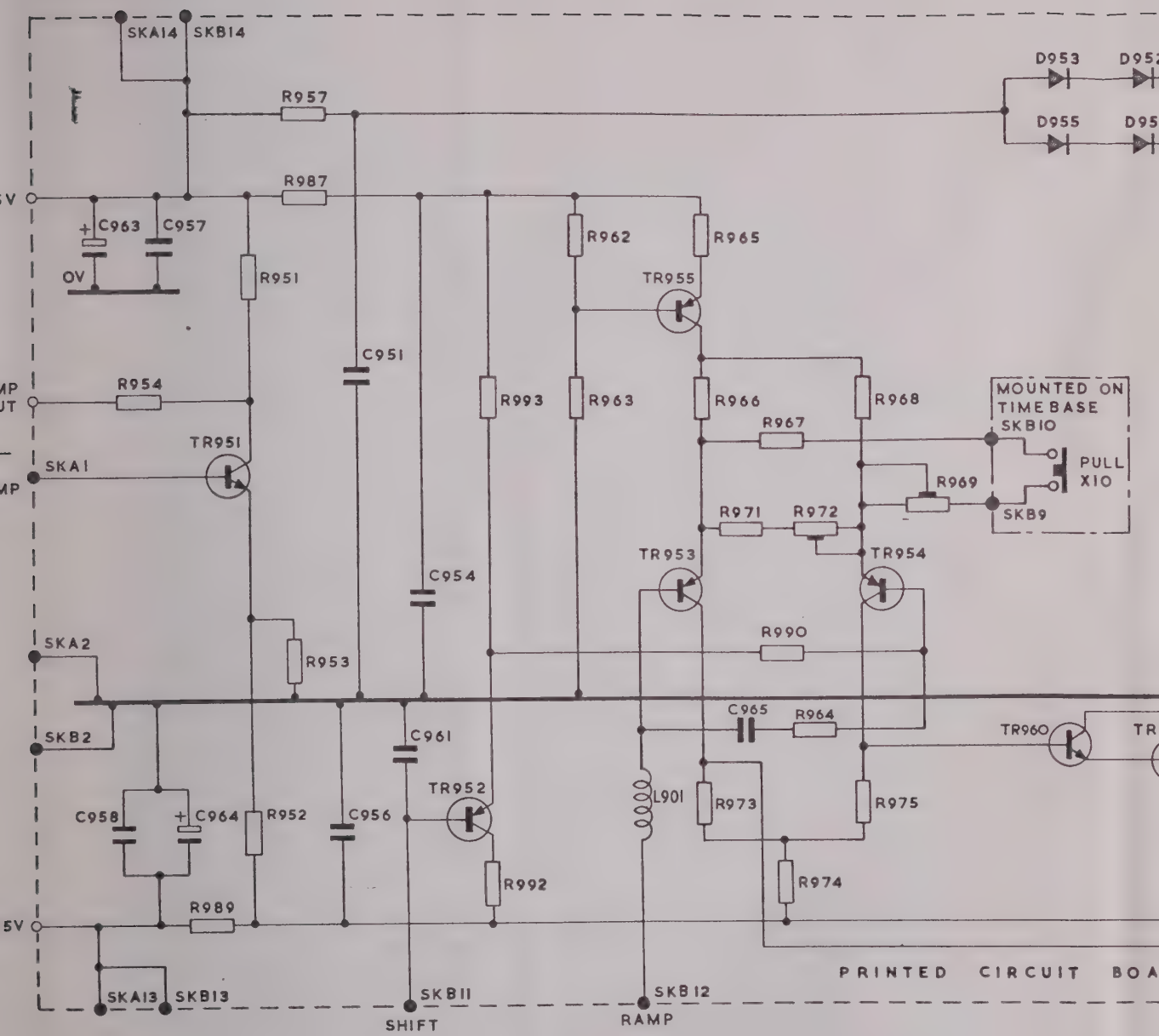


Figure 7. Bright-Up and Z Mod


SKA14
SKB14
R957
D953
D955
R987
C963
C957
OV
R951
R962
R965
TR955
C951
R954
R993
R963
R966
R968
MOUNTED ON TIME BASE SKB10
R967
TR951
SKA1
R969
PULL X10
R971
R972
SKB9
TR953
TR954
C954
R990
SKA2
R953
C965
R964
TR960
SKB2
C961
C958
C964
R952
C956
TR952
L901
R973
R975
R992
R974
R989
5V
SKA13
SKB13
SKB11
SHIFT
SKB12
RAMP
PRINTED CIRCUIT BOA

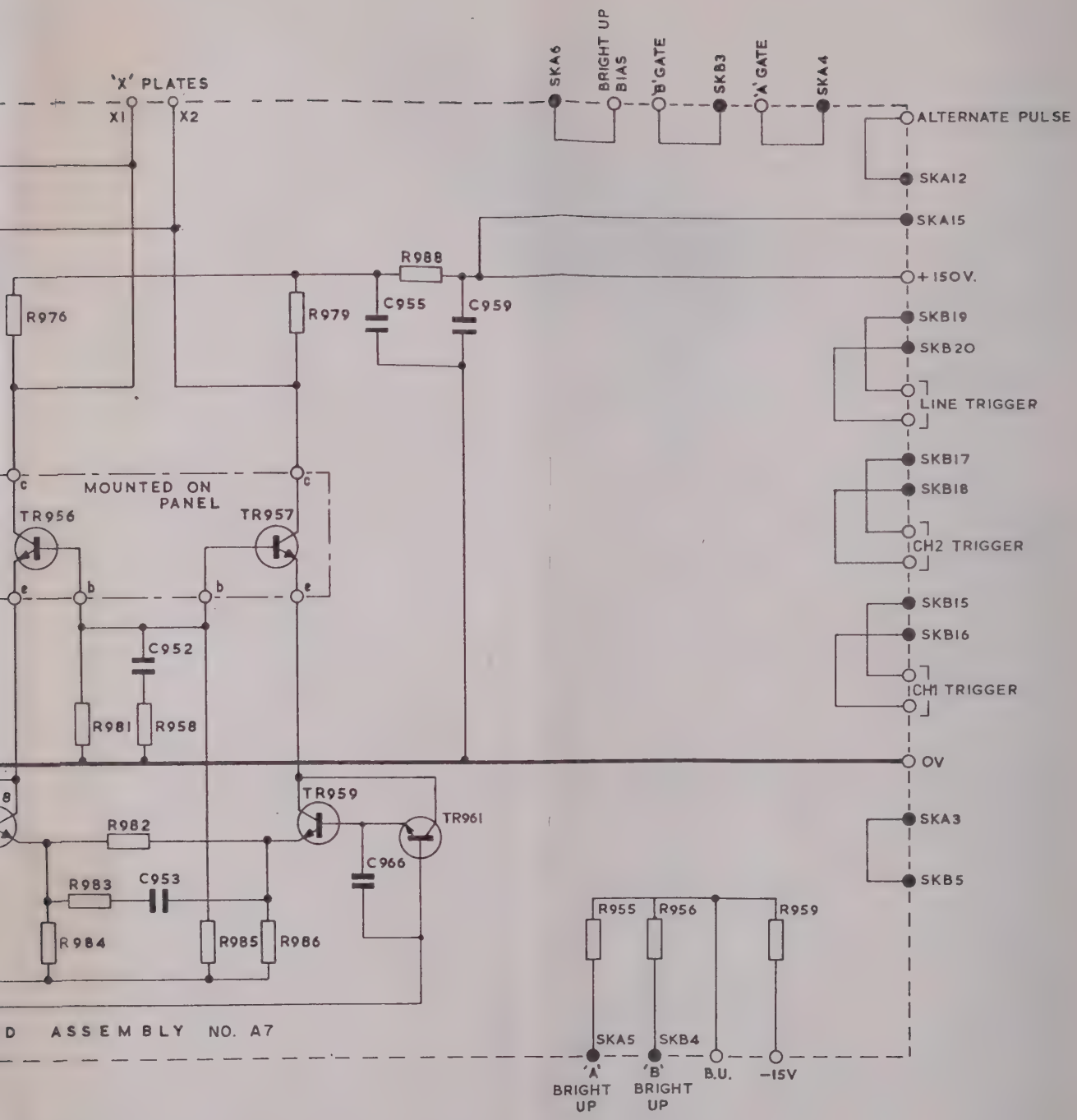
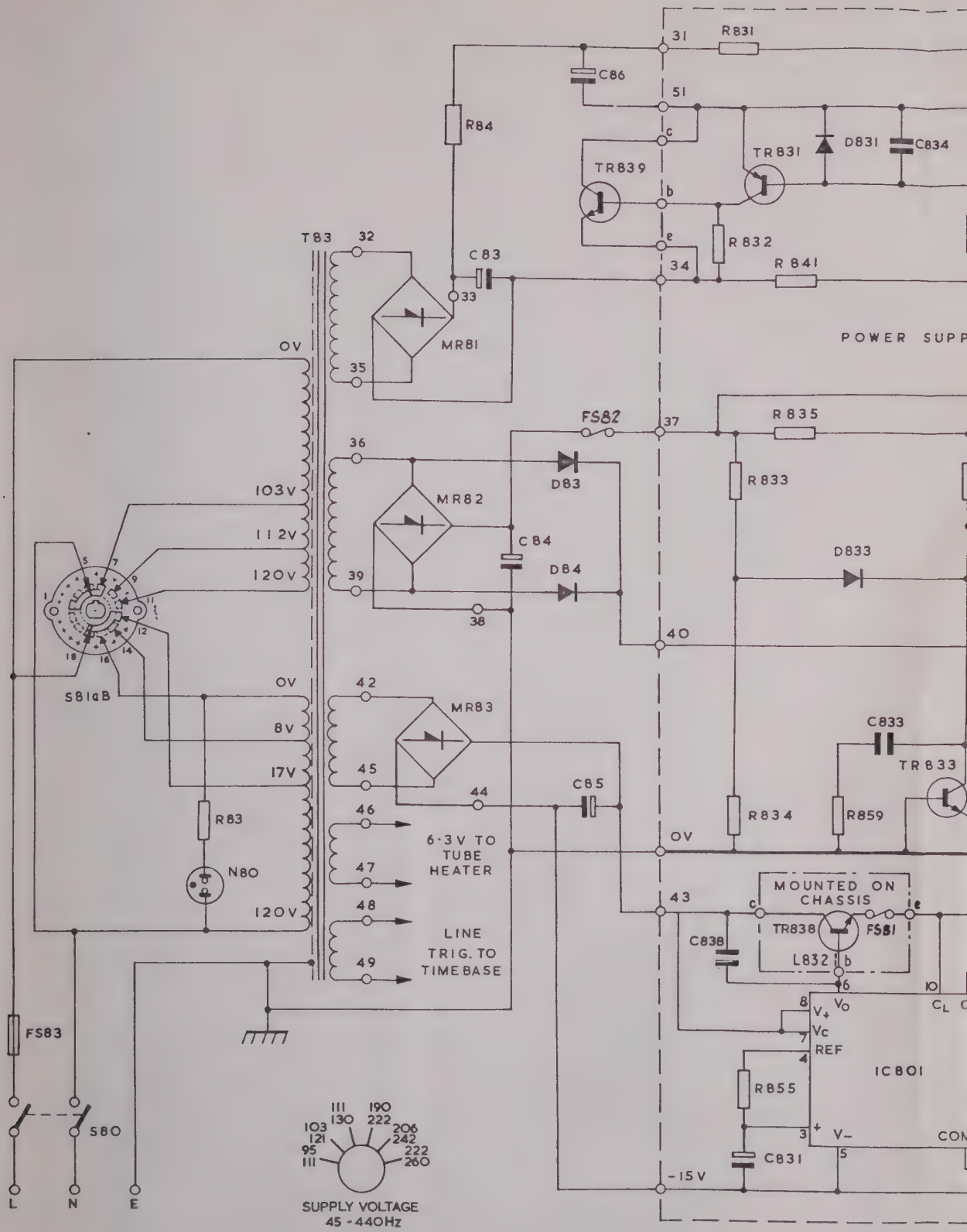


Figure 8. X Output Amplifier



CODING FOR S81
VIEWED FROM
REAR PANEL.

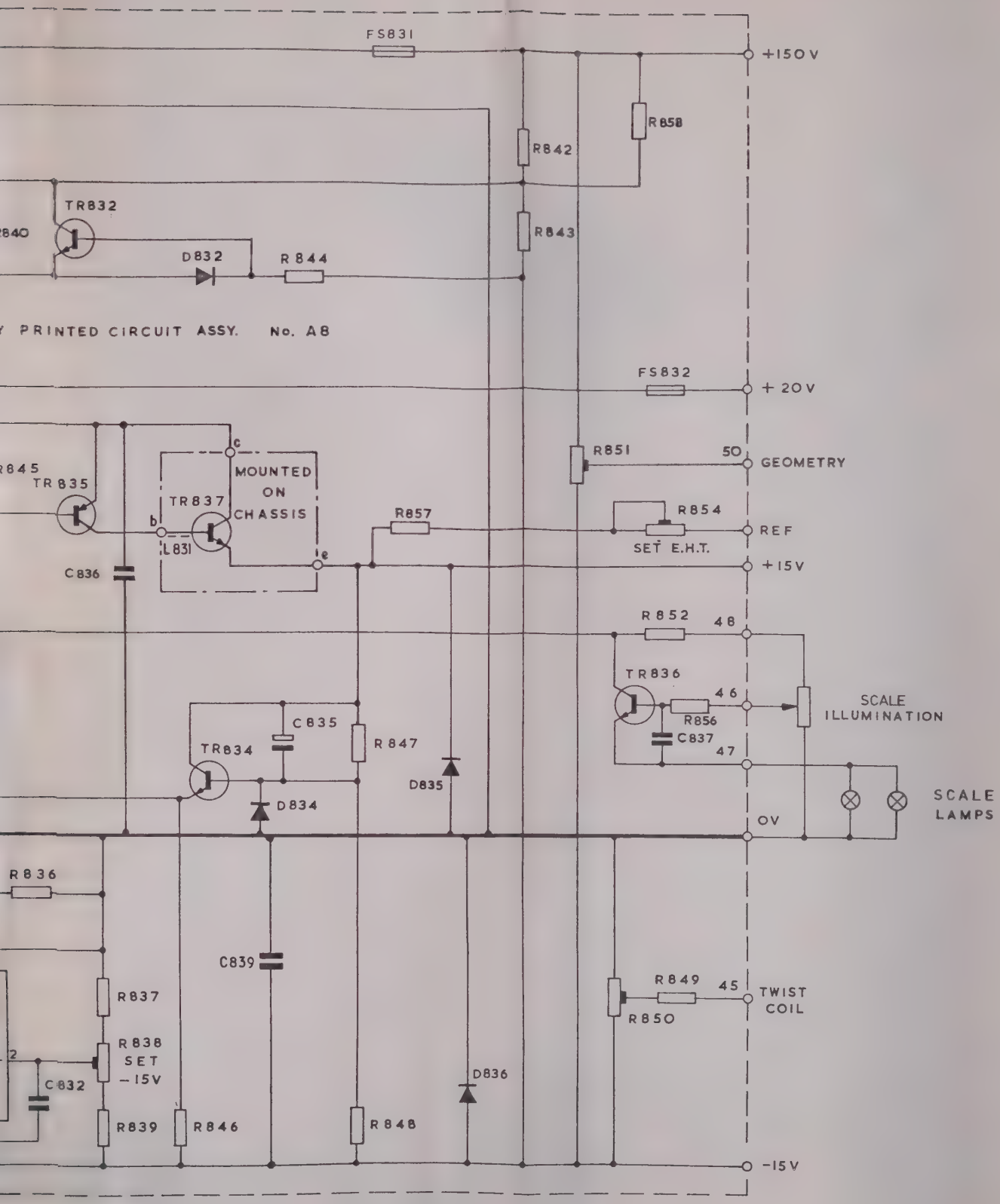
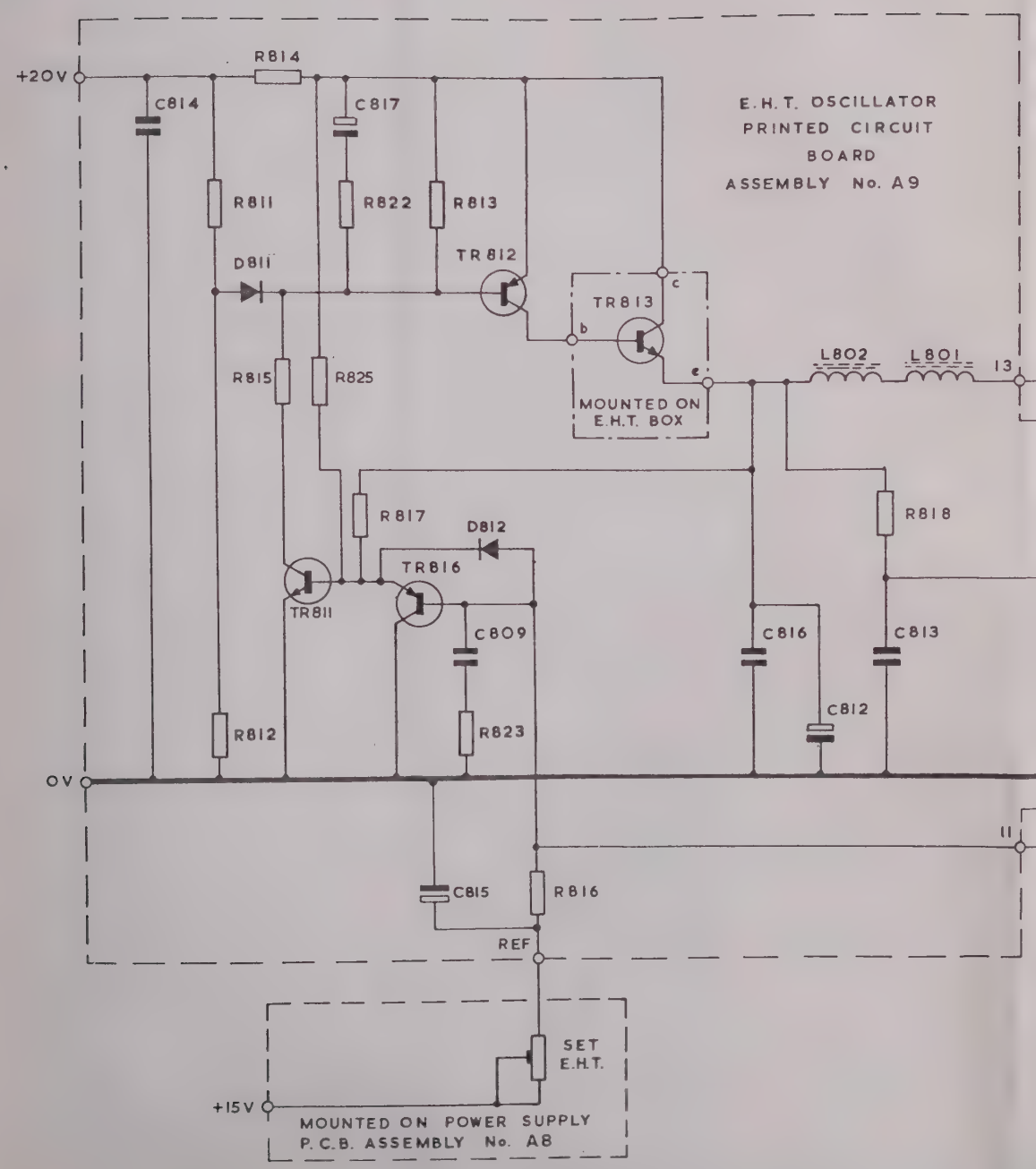


Figure 9. Power Supply


E.H.T. OSCILLATOR
PRINTED CIRCUIT
BOARD
ASSEMBLY No. A9
+20V
R814
C814
C817
R811
R822
R813
D811
TR812
TR813
c
b
e
MOUNTED ON
E.H.T. BOX
L802
L801
13
R815
R825
R817
D812
TR816
TR811
R818
C809
C816
C813
C812
R812
R823
0V
11
C815
R816
REF
SET
E.H.T.
+15V
MOUNTED ON POWER SUPPLY
P.C.B. ASSEMBLY No. A8

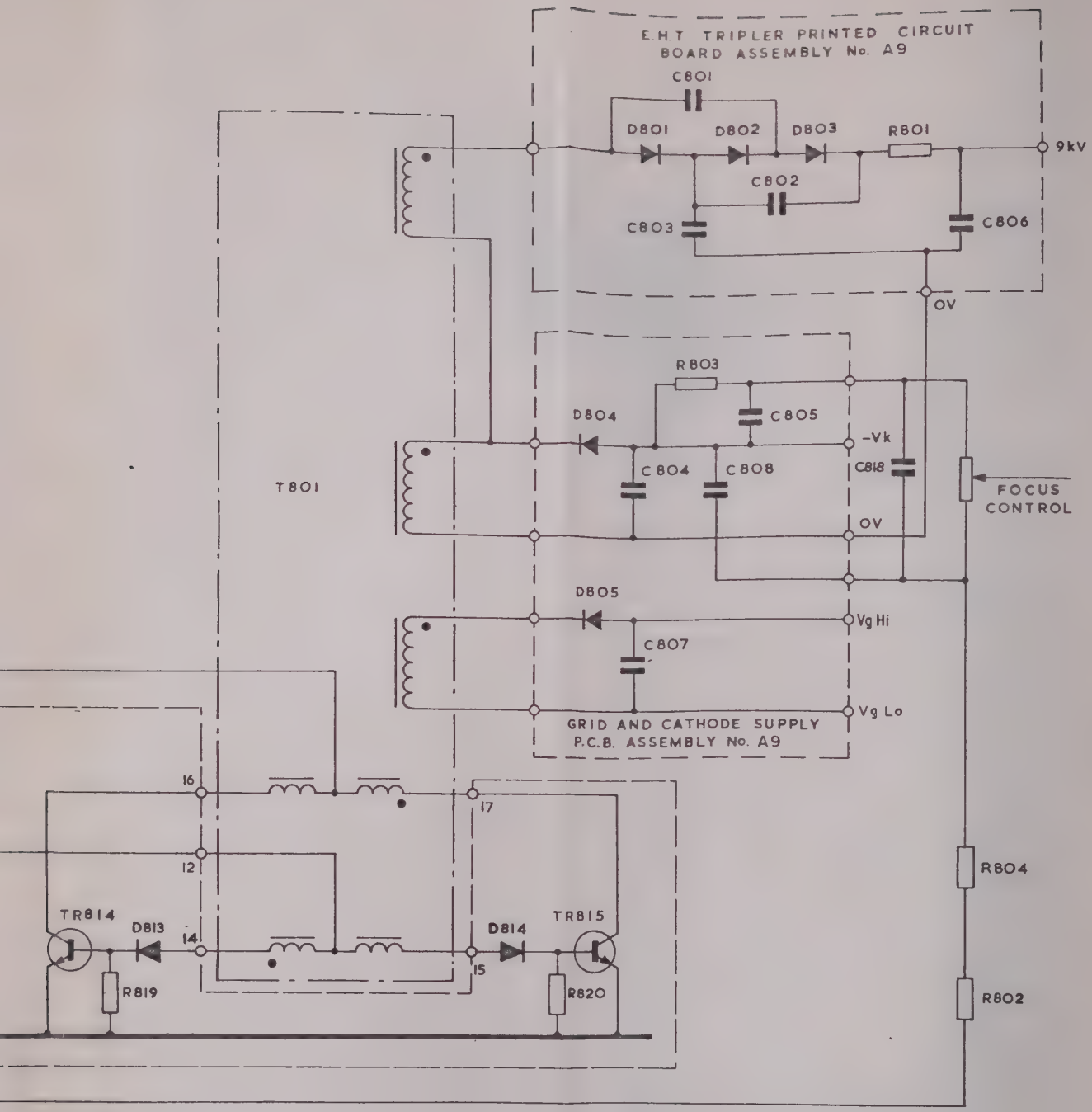
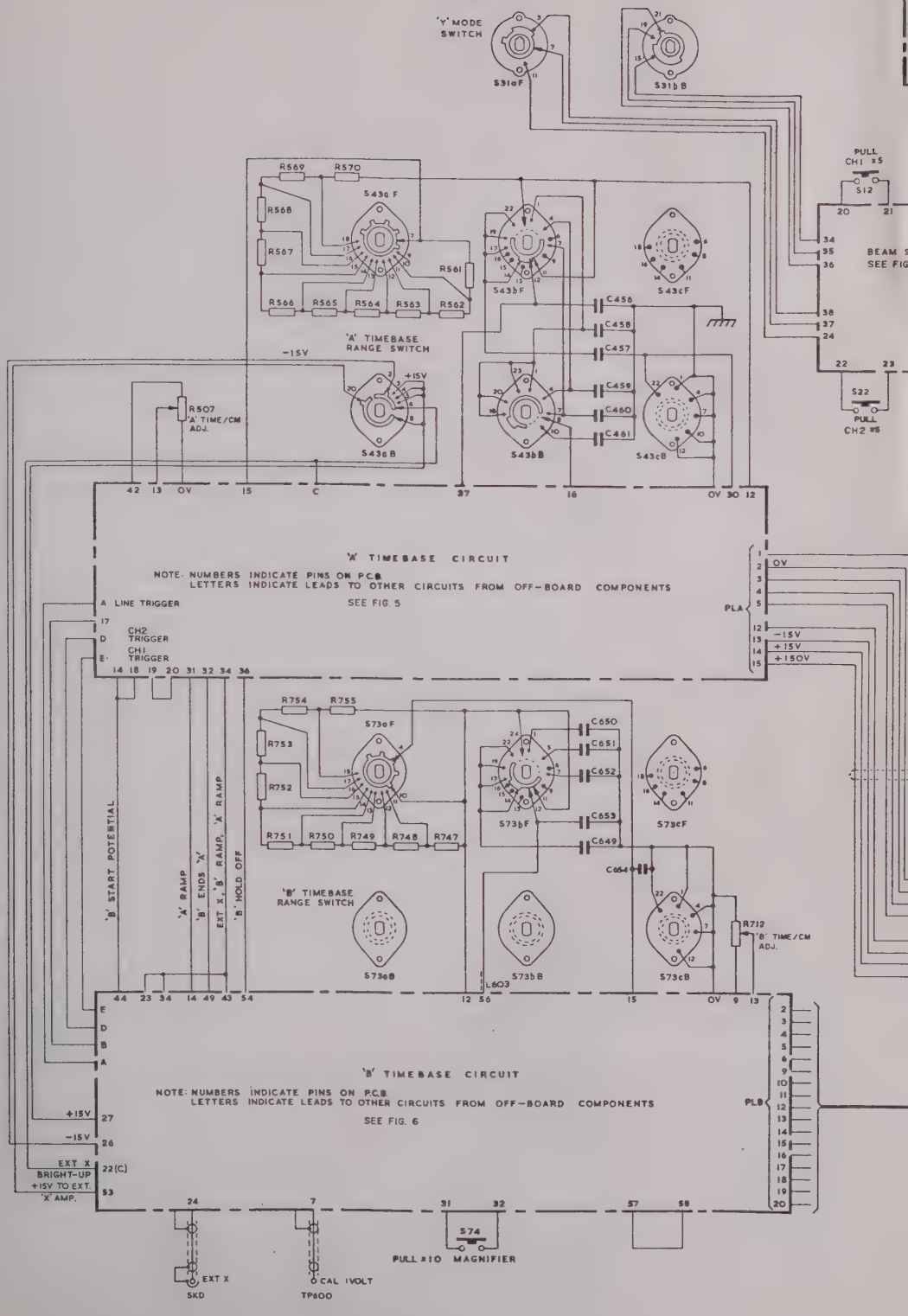


Figure 10. EHT Supply


'Y' MODE SWITCH
S31cF
S31bB
PULL CH1 ×5
S12
BEAM
SEE FIG
R569
R570
R568
R567
R561
R566
R565
R564
R563
R562
S43cF
S43bF
'A' TIMEBASE RANGE SWITCH
-15V
+15V
R507 'A' TIME/CM ADJ.
S43aB
S43bB
S43cB
C456
C458
C457
C459
C460
C461
S22
PULL CH2 ×5
42 13 OV 15 C 37 16 OV 30 12
'A' TIMEBASE CIRCUIT
NOTE: NUMBERS INDICATE PINS ON PCB.
LETTERS INDICATE LEADS TO OTHER CIRCUITS FROM OFF-BOARD COMPONENTS
SEE FIG. 5
A LINE TRIGGER
D CH2 TRIGGER
E CH1 TRIGGER
14 18 19 20 31 32 34 36
PLA
OV
-15V
+15V
+150V
R754
R755
R753
R752
R751
R750
R749
R748
R747
S73aF
S73bF
S73cF
C650
C651
C652
C653
C649
C654
'B' TIMEBASE RANGE SWITCH
S73aB
S73bB
S73cB
R712 'B' TIME/CM ADJ.
L603
'B' START POTENTIAL
'A' RAMP
'B' ENDS 'X'
EXT X, 'B' RAMP, 'A' RAMP
'B' HOLD OFF
44 23 34 14 49 43 54 12 56 15 OV 9 13
E
D
B
A
'B' TIMEBASE CIRCUIT
NOTE: NUMBERS INDICATE PINS ON PCB.
LETTERS INDICATE LEADS TO OTHER CIRCUITS FROM OFF-BOARD COMPONENTS
SEE FIG. 6
PLB
+15V 27
-15V 26
EXT X BRIGHT-UP +15V TO EXT. 'X' AMP. 22(C)
53
24 7 31 32 57 58
S74
PULL ×10 MAGNIFIER
EXT X SKD
CAL 1VOLT TP600

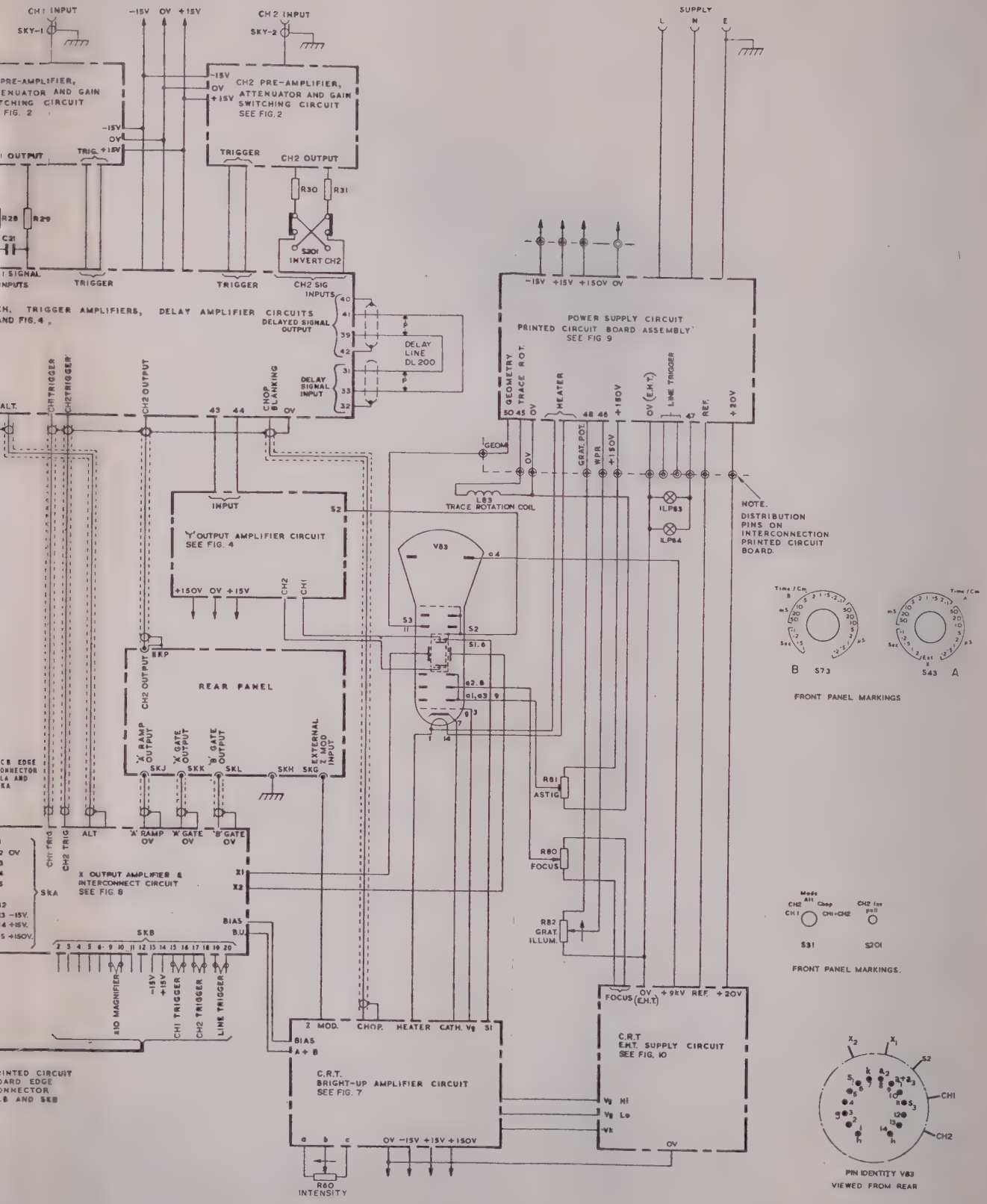


Figure 11. Interconnection Diagram

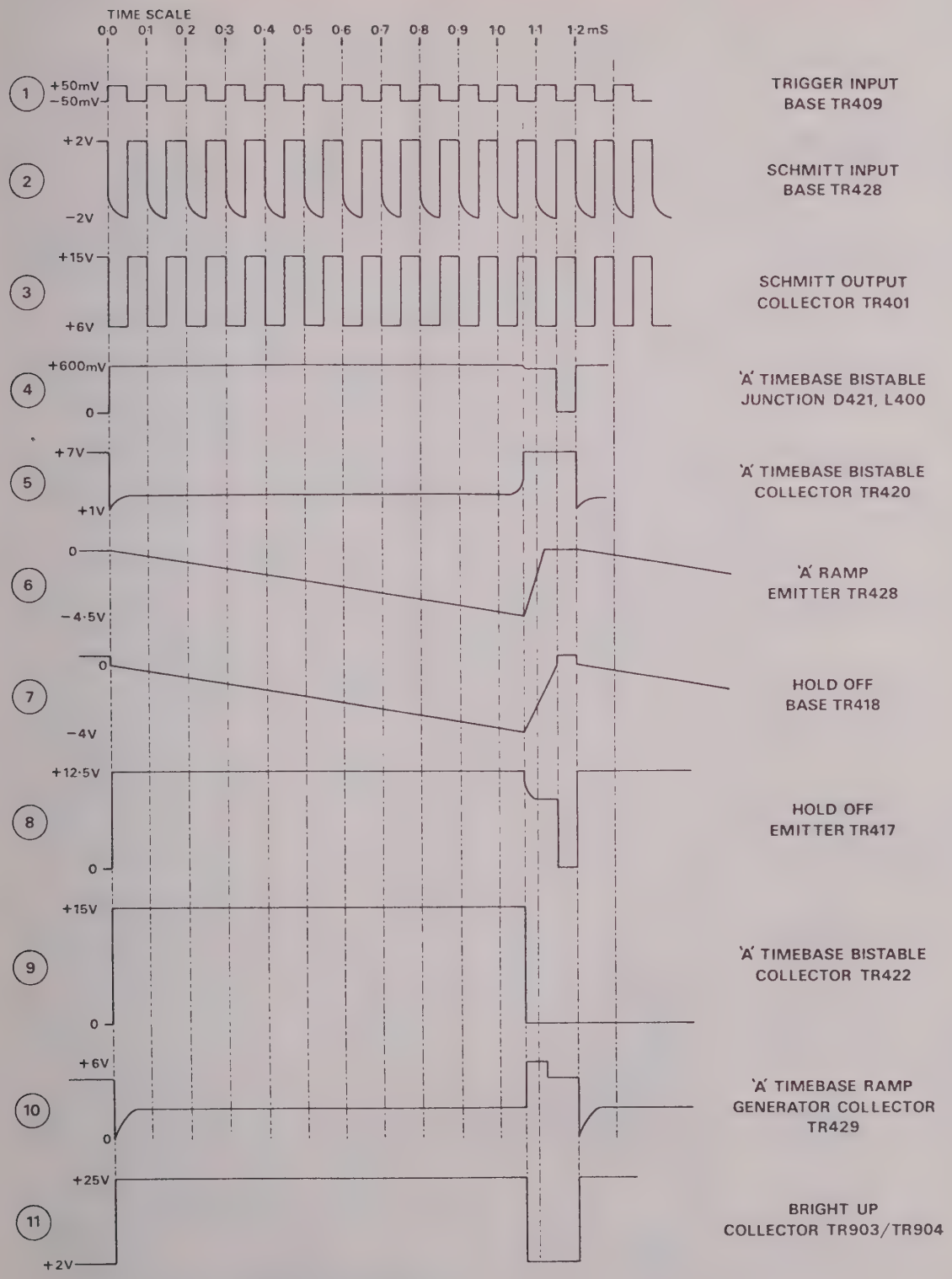


Figure 12. Waveform Diagram Normal A Sweep

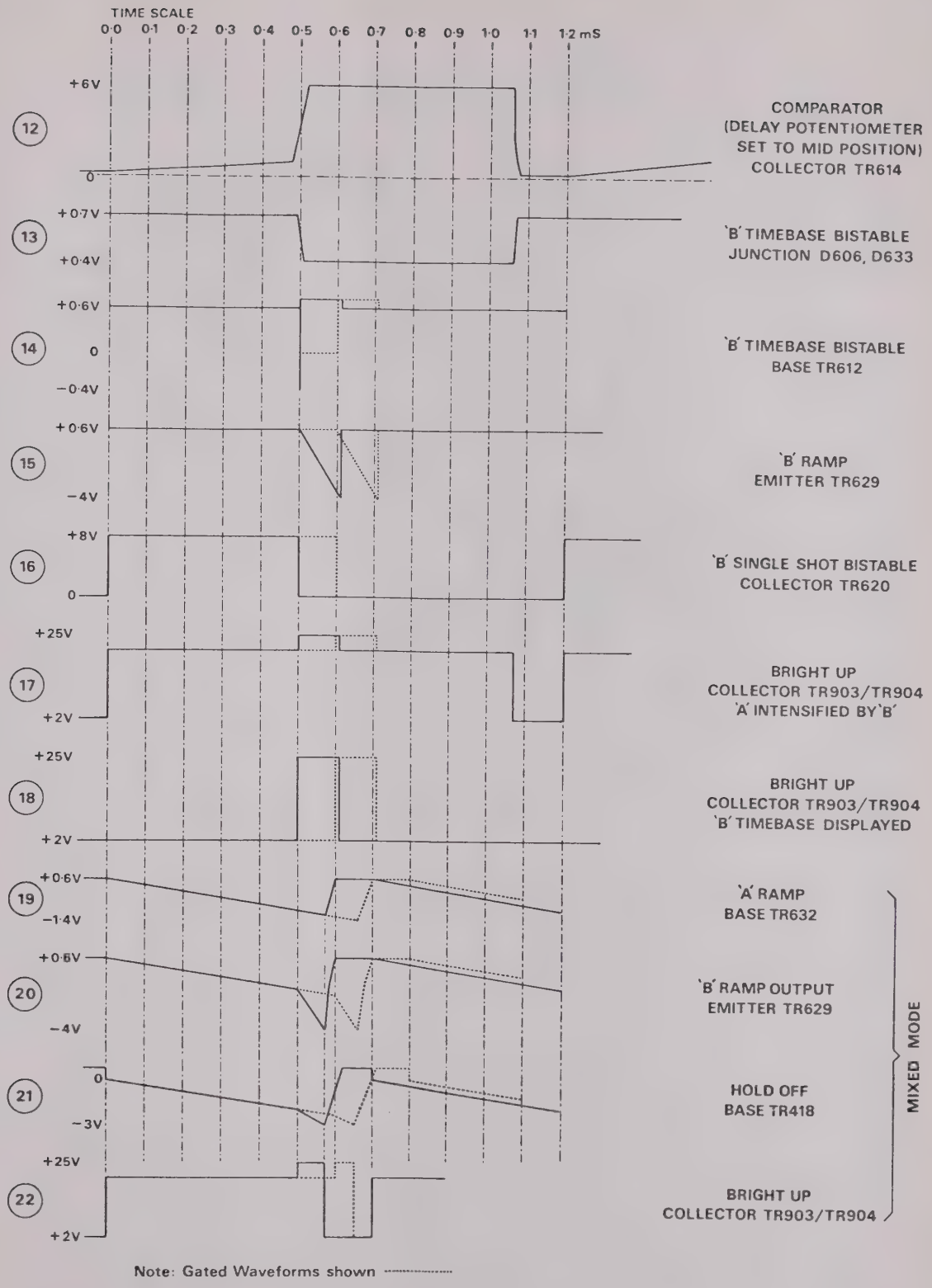


Figure 13. Waveform Diagram Dual Timebase Operation

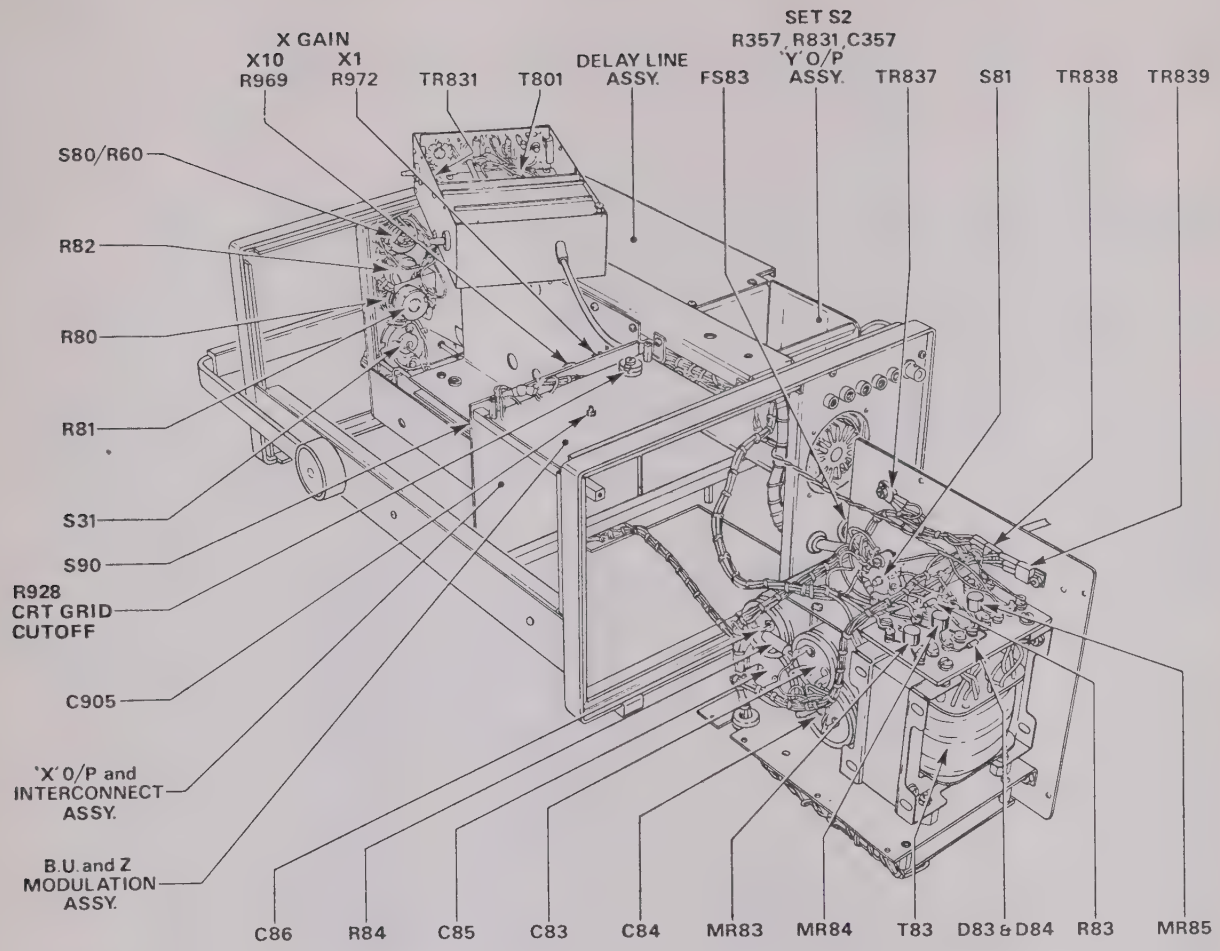
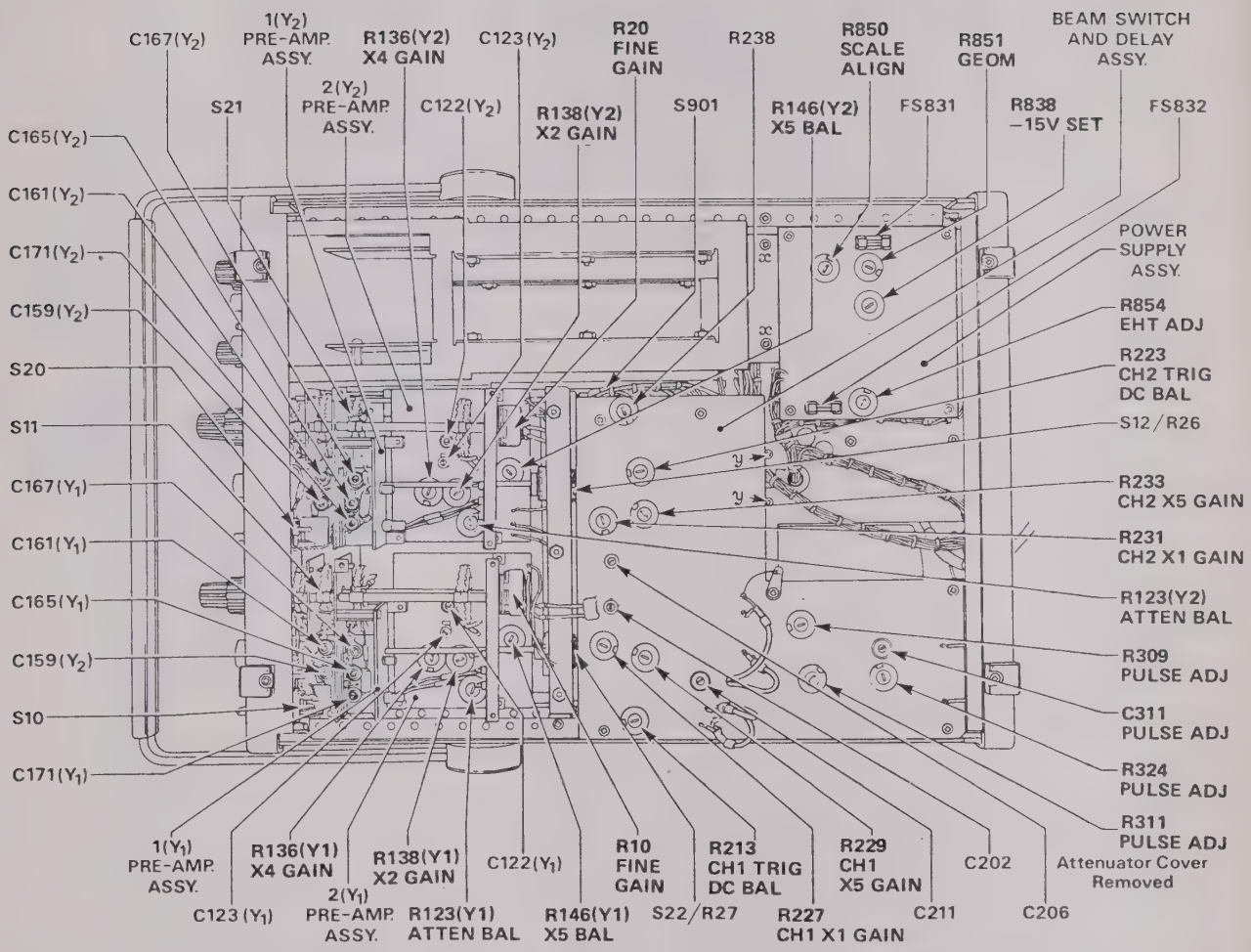


Figure 14. Main Frame Showing Access to Power Supply and EHT Unit



Note: To remove Power Supply Assy. Remove Screws ∞,∞ and y,y. To remove Timebase Assy. loosen Screws ∞,∞

Figure 15. Bottom View

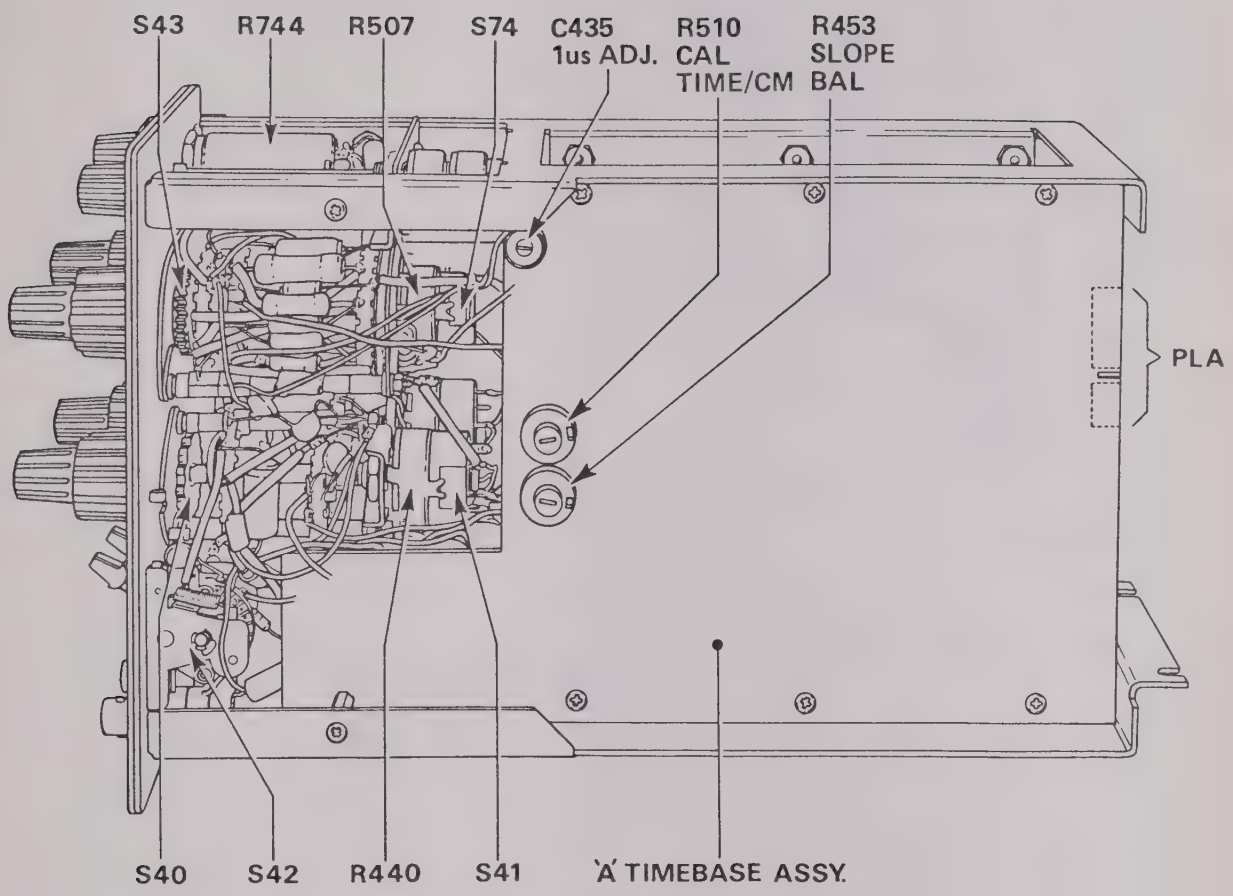


Figure 16. Timebase Unit A Side

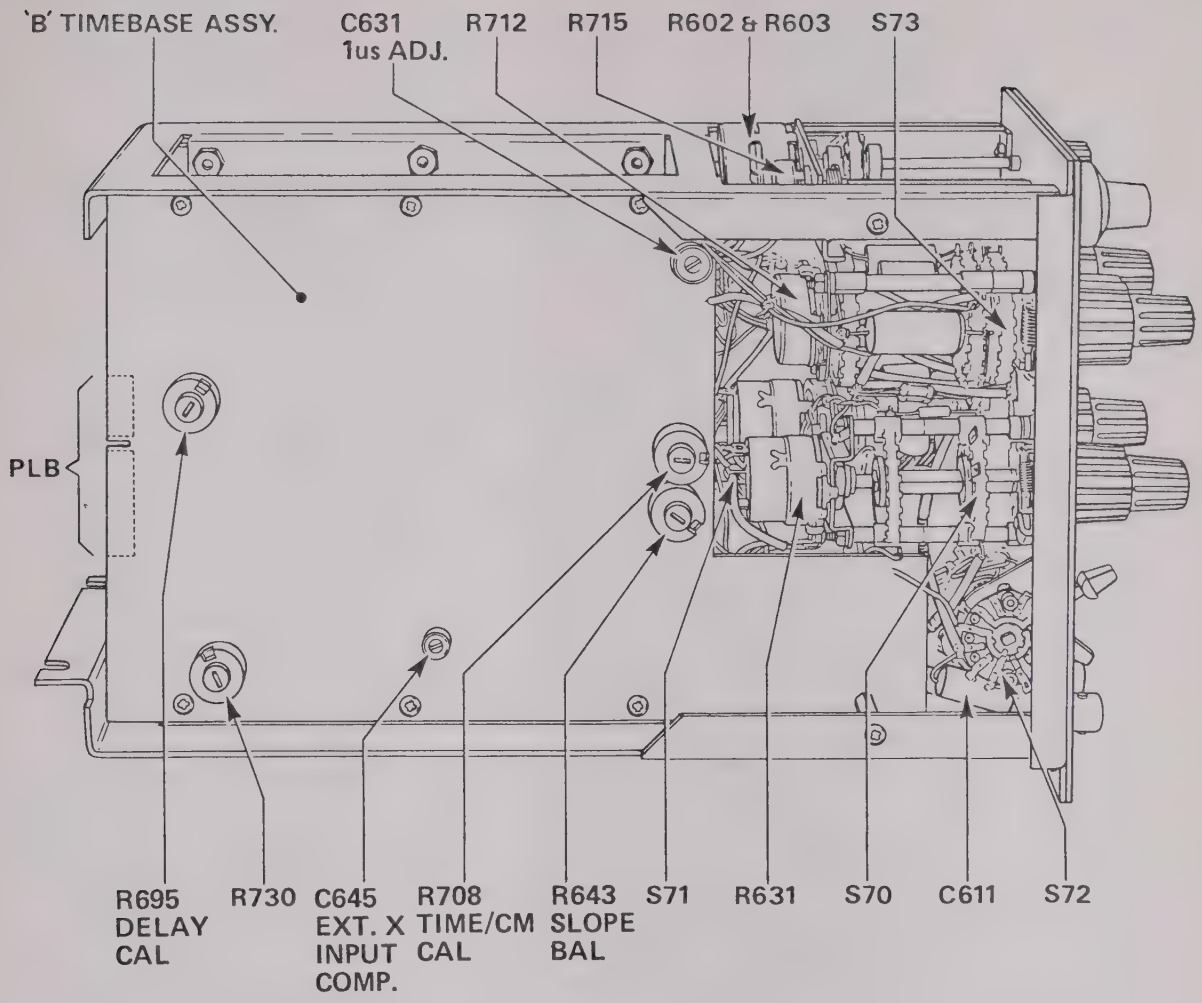
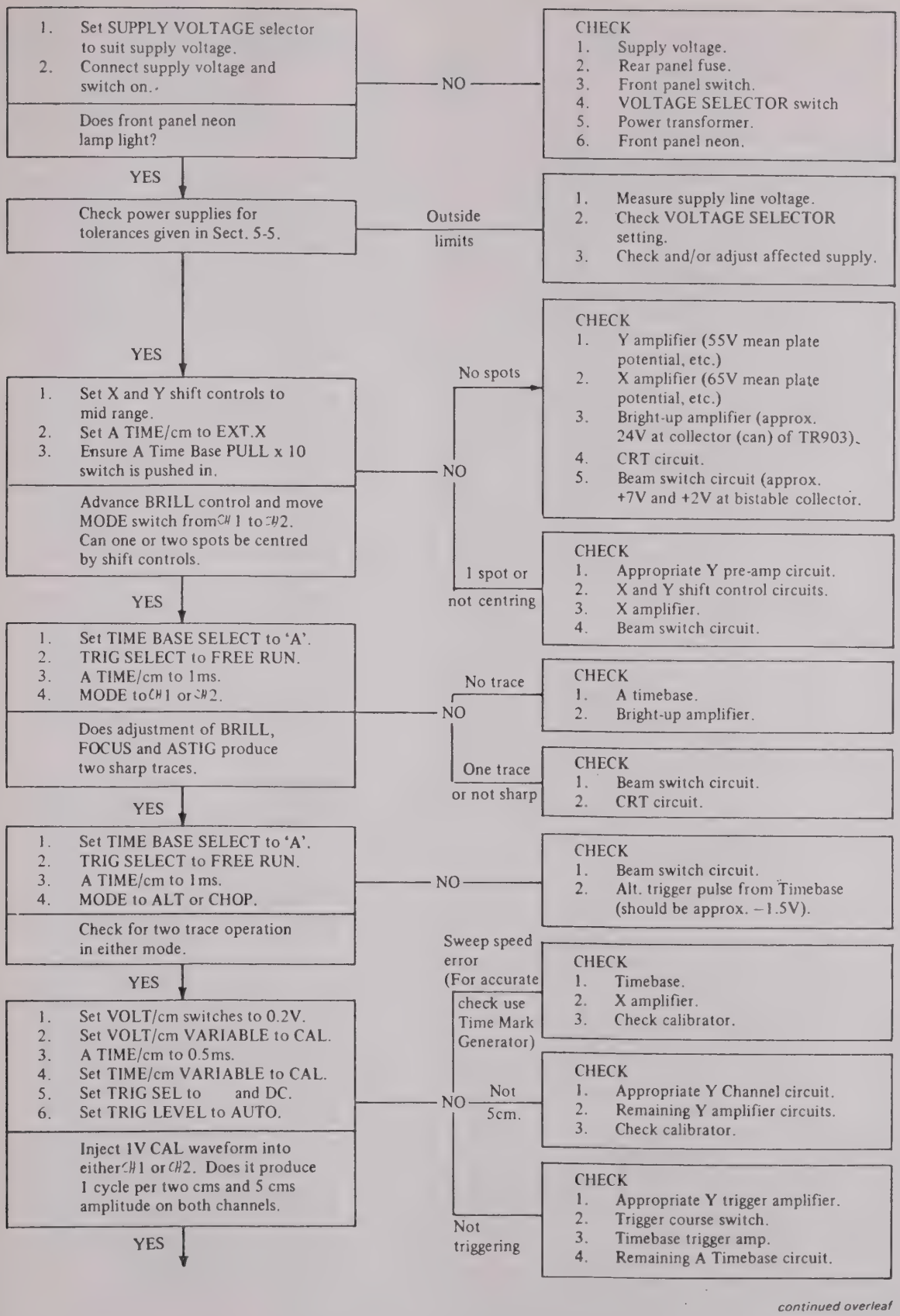


Figure 17. Timebase Unit B Side


1. Set SUPPLY VOLTAGE selector to suit supply voltage.
2. Connect supply voltage and switch on.
Does front panel neon lamp light?
NO
CHECK
1. Supply voltage.
2. Rear panel fuse.
3. Front panel switch.
4. VOLTAGE SELECTOR switch
5. Power transformer.
6. Front panel neon.
YES
Check power supplies for tolerances given in Sect. 5-5.
Outside limits
1. Measure supply line voltage.
2. Check VOLTAGE SELECTOR setting.
3. Check and/or adjust affected supply.
YES
1. Set X and Y shift controls to mid range.
2. Set A TIME/cm to EXT.X
3. Ensure A Time Base PULL x 10 switch is pushed in.
Advance BRILL control and move MODE switch from CH1 to CH2. Can one or two spots be centred by shift controls.
No spots
NO
CHECK
1. Y amplifier (55V mean plate potential, etc.)
2. X amplifier (65V mean plate potential, etc.)
3. Bright-up amplifier (approx. 24V at collector (can) of TR903).
4. CRT circuit.
5. Beam switch circuit (approx. +7V and +2V at bistable collector.
1 spot or not centring
CHECK
1. Appropriate Y pre-amp circuit.
2. X and Y shift control circuits.
3. X amplifier.
4. Beam switch circuit.
YES
1. Set TIME BASE SELECT to 'A'.
2. TRIG SELECT to FREE RUN.
3. A TIME/cm to 1ms.
4. MODE to CH1 or CH2.
Does adjustment of BRILL, FOCUS and ASTIG produce two sharp traces.
No trace
NO
CHECK
1. A timebase.
2. Bright-up amplifier.
One trace or not sharp
CHECK
1. Beam switch circuit.
2. CRT circuit.
YES
1. Set TIME BASE SELECT to 'A'.
2. TRIG SELECT to FREE RUN.
3. A TIME/cm to 1ms.
4. MODE to ALT or CHOP.
Check for two trace operation in either mode.
NO
CHECK
1. Beam switch circuit.
2. Alt. trigger pulse from Timebase (should be approx. −1.5V).
YES
1. Set VOLT/cm switches to 0.2V.
2. Set VOLT/cm VARIABLE to CAL.
3. A TIME/cm to 0.5ms.
4. Set TIME/cm VARIABLE to CAL.
5. Set TRIG SEL to and DC.
6. Set TRIG LEVEL to AUTO.
Inject 1V CAL waveform into either CH1 or CH2. Does it produce 1 cycle per two cms and 5 cms amplitude on both channels.
Sweep speed error (For accurate check use Time Mark Generator)
NO
CHECK
1. Timebase.
2. X amplifier.
3. Check calibrator.
Not 5cm.
CHECK
1. Appropriate Y Channel circuit.
2. Remaining Y amplifier circuits.
3. Check calibrator.
Not triggering
CHECK
1. Appropriate Y trigger amplifier.
2. Trigger course switch.
3. Timebase trigger amp.
4. Remaining A Timebase circuit.
YES

continued overleaf

Figure 18. Fault Localization Chart

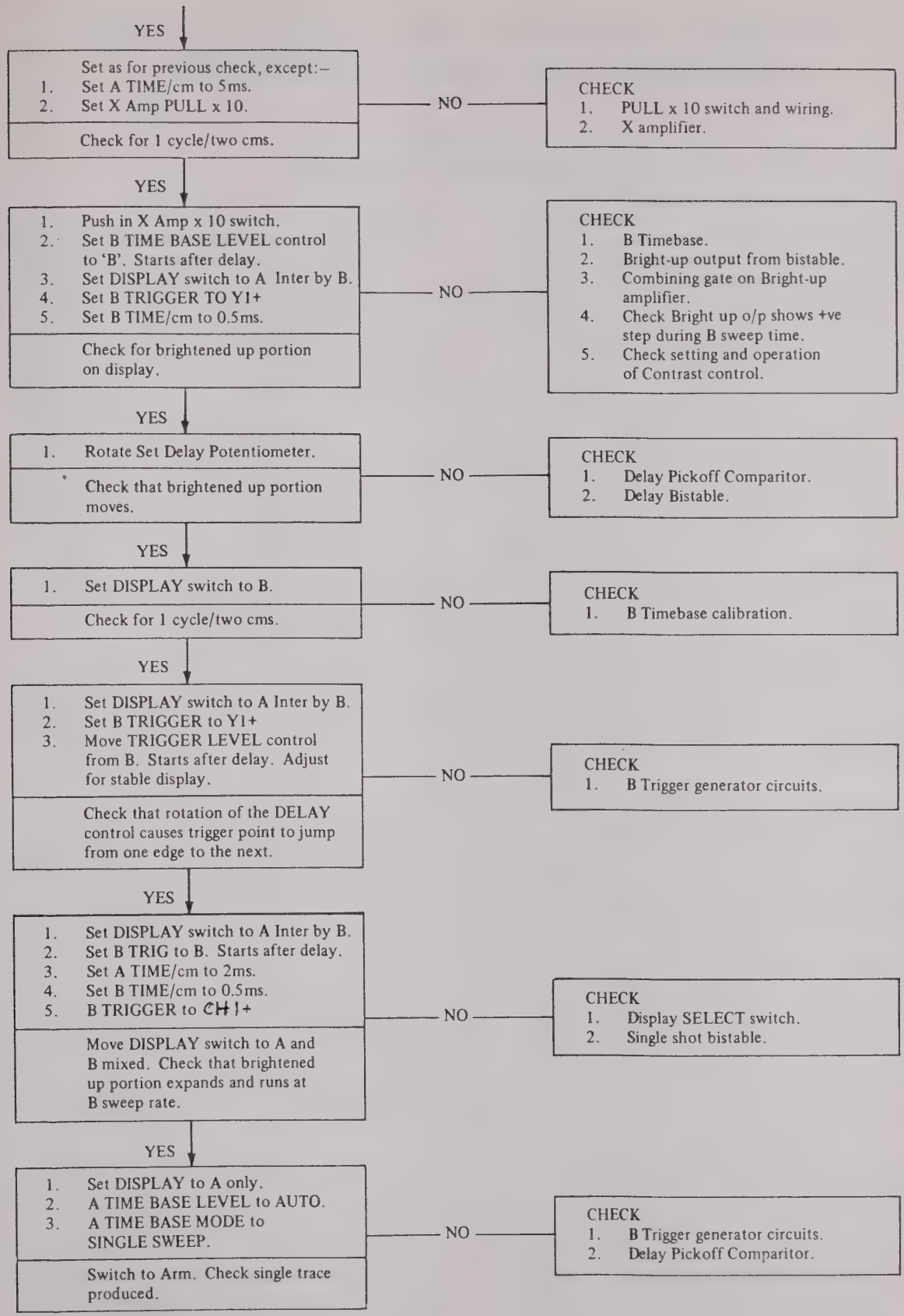

YES
Set as for previous check, except:–
1. Set A TIME/cm to 5ms.
2. Set X Amp PULL x 10.
Check for 1 cycle/two cms.
NO
CHECK
1. PULL x 10 switch and wiring.
2. X amplifier.
YES
1. Push in X Amp x 10 switch.
2. Set B TIME BASE LEVEL control to 'B'. Starts after delay.
3. Set DISPLAY switch to A Inter by B.
4. Set B TRIGGER TO Y1+
5. Set B TIME/cm to 0.5ms.
Check for brightened up portion on display.
NO
CHECK
1. B Timebase.
2. Bright-up output from bistable.
3. Combining gate on Bright-up amplifier.
4. Check Bright up o/p shows +ve step during B sweep time.
5. Check setting and operation of Contrast control.
YES
1. Rotate Set Delay Potentiometer.
Check that brightened up portion moves.
NO
CHECK
1. Delay Pickoff Comparitor.
2. Delay Bistable.
YES
1. Set DISPLAY switch to B.
Check for 1 cycle/two cms.
NO
CHECK
1. B Timebase calibration.
YES
1. Set DISPLAY switch to A Inter by B.
2. Set B TRIGGER to Y1+
3. Move TRIGGER LEVEL control from B. Starts after delay. Adjust for stable display.
Check that rotation of the DELAY control causes trigger point to jump from one edge to the next.
NO
CHECK
1. B Trigger generator circuits.
YES
1. Set DISPLAY switch to A Inter by B.
2. Set B TRIG to B. Starts after delay.
3. Set A TIME/cm to 2ms.
4. Set B TIME/cm to 0.5ms.
5. B TRIGGER to CH1+
Move DISPLAY switch to A and B mixed. Check that brightened up portion expands and runs at B sweep rate.
NO
CHECK
1. Display SELECT switch.
2. Single shot bistable.
YES
1. Set DISPLAY to A only.
2. A TIME BASE LEVEL to AUTO.
3. A TIME BASE MODE to SINGLE SWEEP.
Switch to Arm. Check single trace produced.
NO
CHECK
1. B Trigger generator circuits.
2. Delay Pickoff Comparitor.

Figure 18. Fault Localization Chart (Continued)

OSCILLOSCOPE VHF & GENERAL PURPOSE BALLANTINE 1040A MOD 49 SERIES

SECTION 1
GENERAL INFORMATION

The Ballantine 1040A MOD 49 Series of oscilloscopes are high performance portable precision dual trace oscilloscopes which include a full capability delaying sweep as well as modifications to permit the instrument to be used for general purpose maintenance as well as VHF amplitude modulation phase comparisons in VOR and TACAN navigation systems. The VHF modifications include:

1. 75 and 108 to 148 MHz tuned inputs to the vertical deflection plates.
2. X amplifier output test points.
3. Marker input to the Y axis.

Two units are available:

1040A MOD 49A – Consists of the basic instrument with two instruction manuals.

1040A MOD 49B – Consists of the basic instrument with two instruction manuals and a cable kit consisting of seven RG62/U coaxial cables cut to length for use as VHF input cables at 75 MHz and in the 108 to 148 MHz band.

Optional Accessory Kit, MOD 101, is also available and consists of:

2 each 10:1 Attenuator probes Ballantine Model 10601C.
1 each Protective Cover, Front Panel Ballantine Model 10750A.

The Ballantine Model 1040A MOD 49 Cathode-ray Oscilloscope is designed for use either as a narrow band amplitude modulation monitor or as a general purpose cathode-ray oscilloscope. It is appropriate for use in the alignment and maintenance of VHF instrument landing systems, omnirange and communication transmitters. The performance of this instrument can be determined by referring to the specification for a 1040A scope.

The oscilloscope is a standard Ballantine Model 1040A portable 40 MHz, dual trace, transistorized scope. The VHF circuitry is built on a bracket fastened near the rear panel and over the CRT neck. The VHF mounting bracket contains the tuning capacitor and frequency range switching as well as the X amplifier test points and the VHF/NORM operation switch. Use the Model 1040A instruction manual and this addendum.

By means of the switch mounted on the VHF bracket (see Schematic Figure A-5) it is possible to switch the CRT vertical deflection plates from the circuits employed for general purpose applications to the VHF circuit. This special application for which the instrument is basically designed will permit monitoring of amplitude-modulated r-f carriers in the range of 108 to 148 MHz and at 75 MHz. A 4-position slide switch optimizes the VHF input to the input frequency range and permits further attenuation and amplitude control of input signals.

SPECIFICATIONS

All the specifications of the Ballantine 1040A dual trace, portable oscilloscope apply with the following exceptions:

Vertical Bandwidth: dc to 36 MHz (–3 dB) each channel
Horizontal Bandwidth: dc to 750 kHz (–3 dB)
Magnifier X10: Accuracy at 50 nS/cm and 20 nS/cm ranges ±8% after initial 60 nS.
Phase Shift: <1° dc to 40 kHz and <3° dc to 100 kHz at 5 mV/cm
Dimensions: Height: 178 mm (7 in.)
Width: 289 mm (11-3/8 in.)
Depth: 422 mm (16-5/8 in.)
Weight: 11 kg. (24.2 lbs.)
Shipping Weight: 15 kg. (33 lbs.)

ACCESSORIES (Supplied)

1040A MOD 49A

1 each Power Cord, 6 feet, p/n 33-10000-0A
2 each Instruction Manuals 1040A and Addendum for MOD 49A

1040A MOD 49B

1 each Power Cord, 6 feet, P/N 33-10000-0A
2 each Instruction Manual 1040A and Addendum for MOD 49A
1 each VHF Cable Kit, P/N 89-10199-1A (includes seven (pre-cut) cables)

ACCESSORIES (Optional)

Cable, coaxial BNC to BNC, 120/cm (48 inches), Model 12249D
Cable, coaxial BNC to BNC, 21/cm (8 inches), Model 12249A
Probe, attenuator, X10, X1 & GND. REF., 120cm (48 inches) Model 10601C
Probe, RF Detector usable to 700 MHz Model 10850A
Cable, shielded BNC to alligator clip, 120 cm (48 inches), Model 12250A
Termination, 50Ω BNC to BNC, 2W, Model 12630A
Kit Cable – VHF P/N 89-10199-1A
Adapter, BNC female to Type N male, UG201-U
RG-62/U, BNC to BNC, cut to 3/4 wave length (without adapter)
W7 – 75 MHz
W1 – 110 MHz
W2 – 113 MHz
W3 – 116 MHz
W4 – 125 MHz
W5 – 135 MHz
W6 - 145 MHz

Accessory Kit MOD 101:

2 each attenuator Probes Model 10601C
1 each Cover, Panel Protection, Model 10750A.
Time Mark Generator, Model 6130A.
Oscilloscope Calibrator Model 6125B
Electrical Signal Recorder – records transients on endless magnetic tape loop, Model 7050A

Soft Luggage Style Instrument Cover, Model 10725A
Viewing Hood, 8 x 10 cm, Model 10702A

VHF AMPLITUDE MODULATION MONITOR

Deflection Signals: Amplitude modulated carrier selected by slide switch to apply the normal general purpose scope amplifier or the VHF input to the vertical deflection plates of the CRT.

Carrier Frequency Ranges: 108 to 148 MHz in three switches selectable ranges; 75 MHz, ±300 kHz on the fourth range.

Maximum Input Voltage: 100 Volts rms or 300 Volts peak to peak measured at input of odd multiple 1/4 wave lengths with RG-62/U cable driven from 50Ω source.

Minimum Deflection Sensitivity: ⩾2 Volts rms/cm (5.6 V p-p/cm) measured at 145 MHz.

Input Coupling: 93 ohm coaxial cable, RG-62/U, cut to odd multiple 1/4 wave lengths matched to internal coupling link.

Input Impedance: At least 500Ω at input of odd multiple of 1/4 wave lengths cable.

Signal Attenuation: A continuously adjustable VHF tuning control is provided which permits VHF vernier gain adjustment range of at least 30 dB (33 to 1) on the 108 to 148 MHz ranges when used with the range selector switch (Hi-Low-Medium positions). 10 dB of continuous attenuation is provided on the 75 MHz range.

Vertical Position Range: Same as for general purpose operation.

HORIZONTAL AMPLIFIER TEST POINTS

Two tip jacks are provided on the top of the instrument; one tip jack for each of the push-pull outputs of the horizontal deflection amplifier. The plus (+) test point provides a positive going signal when the trace moves to the right on screen. The minus (–) test point provides a negative going signal when the trace moves to the right on screen.

Output Coupling: DC coupled for minimum phase shift.

Output Signal Voltage: Greater than 4 Volts/cm into >1 MΩ (at dc)

Output Common Mode Voltage: Nominally 50 to 75 Volts dc.

Short Circuit: A 10 kΩ 1 Watt series current limiting resistor is provided for each tip jack. The tip jack may be continuously shorted to ground without damage to the instrument. A third tip jack is provided for access to chassis ground.

Marker Injection

Input Resistance: Nominally 50 ohms

Sensitivity: At least 1 volt per cm

Max. Input Voltage: ±2.5Volts (dc + peak ac). ±1 Volt dc max. Input Power 1/2W Max.

Rise Time: ≈ 11 nanoseconds

Applicability: Installed in units with serial number prefix 030-XXXX and above.

Cathode-ray Tube

8 x 10 cm internal graticule 10 kV CRT. Internal graticule has dark grid lines for easy daylight viewing in ambient light. Illumination is provided to floodlight entire screen background at low levels. This CRT illumination is intended only for oscilloscope photography.

SECTION 2
OPERATION

2.1 GENERAL

By means of Switch S1001 mounted on the VHF bracket, it is possible to switch the CRT vertical-deflection plates from the circuits employed for general purpose oscilloscope application to the VHF circuit. This special application, for which the instrument is basically designed, will permit monitoring of amplitude modulated VHF carriers in the range from 108 to 148 MHz and at 75 MHz. (See Fig. A-1).

2.2 CABLE FABRICATION FOR VHF CIRCUIT

2.2.1 Option VHF Cable Kit P/N 89-10199-1A provides seven input cables of seven frequencies: 75, 110, 113, 116, 125, 135, and 145 MHz. If VHF Modulation monitoring is required at frequencies other than 75, 110, 113, 116, 125, 135, or 145 MHz, it will be necessary to cut one of the cables to the required length for the desired frequency. The length of the finished cable must not vary by more than ±1/6 inch from that specified on the chart. Note that the cable length is measured from the tip of one connector to the tip of the other, even though the tips may be recessed in the bodies of the connectors.

2.2.2 The seven RG-62/U cables supplied with the kit are equipped with Type UG-260/U connectors at each end. Through the use of a Type UG-201/U adapter at the input end of the cable, connection may be made to type "N" receptacles. The addition of the Type UG-201/U adapter lengthens the cable, hence, the cable must be recut to length according to Curve B on the Frequency Versus Length Chart Fig. A-3 to maintain the original frequencies for which the cables were designed (75, 110, 113, 116, 125, 125, and 145 MHz). In addition, Curve B of this chart may be used to determine other frequency lengths, when desired, for operation with the Type UG-201/U adapter.

2.3 CIRCUIT DESCRIPTION

The VHF circuit is as shown in the simplified schematic, Figure A-4. Input to the system is provided by a three-quarter wavelength coaxial line terminated at the oscilloscope in a very low impedance coupling loop L1007. The loop L1007 is coupled to a balanced VHF tank circuit consisting of inductors L1005 and L1006 and VHF TUNING capacitor C1001. The VHF TUNING control is an adjustment to facilitate tuning to the desired frequency and to provide a sensitivity adjustment. For a given frequency, tuning to resonance gives maximum deflection, while detuning reduces the deflection; thus a continuously variable means is provided for controlling the degree of signal attenuation. In addition, a 4-position slide switch S1002 provides coarse adjustment (HI-MED-LO) in the 108 to 148 MHz range and it also provides a 75 MHz range.

The amount of coupling between the link L1007 and the tank circuit (L1005, L1006, C1001) determines both the sensitivity and input impedance. Closer coupling results in higher sensitivity and lower input impedance; conversely, looser coupling results in lower sensitivity and higher impedance. The link L1007 is designed to provide the best compromise between sensitivity and impedance.

The use of split-stator capacitor for the VHF TUNING control C1001 facilitates balancing of the VHF circuit for push-pull deflection. In order to provide positioning voltage for the vertical deflection plates of the CRT, the VHF transformer tank coils split into the two coils L1005 and L1006 by d-c blocking capacitor C1002. Positioning voltage is applied through decoupling resistors R1001 and R1002.

C1005 is a variable trim capacitor which is adjusted to pad the tank circuit to provide LO tuning range to 108 MHz. In MED tuning range C1003 and C1004 are placed in series with C1005. C1006 is a variable capacitor which is preset to resonate the tank circuit to 75 MHz when C1001 is at mid-range.

By employing input cables of length equal to an odd multiple of a quarter wave, suitable coupling to the oscilloscope may be obtained. The low effective impedance at the oscilloscope end of the cable, where it is terminated in a coupling link strategically placed at the center of the balanced tank coil, appears as a relatively high impedance at the input end which connects to the VHF source.

In a transmission line having an equivalent length of odd multiples of a quarter wave, the geometric mean of the input and output impedances is equal to the characteristic impedance of the transmission line. Therefore, use of a 93 ohm line assures a minimum of 500 ohms input impedance over the entire frequency range for which the Ballantine Model 1040A MOD 49 is designed.

The leads associated with the Y-positioning system having inductance which may resonate with S1001 switch stray capacities. Low "Q" ferrite bead chokes, L1001, L1002, L1003, and L1004 increase this inductance, thus lowering this resonant frequency below the operating range of the VHF circuit. VHG "suckout" is thus prevented throughout the operatngi range of the instrument with resulting equalized sensitivity over the entire range.

2.4 X AMPLIFIER OUTPUT TEST POINTS

The output of the X amplifier is a push-pull signal to the horizontal deflection plates of the CRT.

A tip jack is provided to sample the voltage at each plate of the CRT. This permits 30 Hz phase compensation of the omnirange test generator by nulling out the 30 Hz phase shift of the X amplifier of the oscilloscope.

Two tip jacks are provided to obtain access to each horizontal deflection plate of the CRT.

The tip jacks are dc coupled to avoid phase shift at 30 Hz. A 10 kΩ series resistor is provided for each red tip jack to limit "short circuit to ground" current to approximately 10 mA.

Continuous grounding of the test points should be avoided but will not damage the oscilloscope.

NOTE Disconnect all wiring or loading at the X test points when using the oscilloscope as a general purpose instrument. This assures specified X deflection and time base calibration.

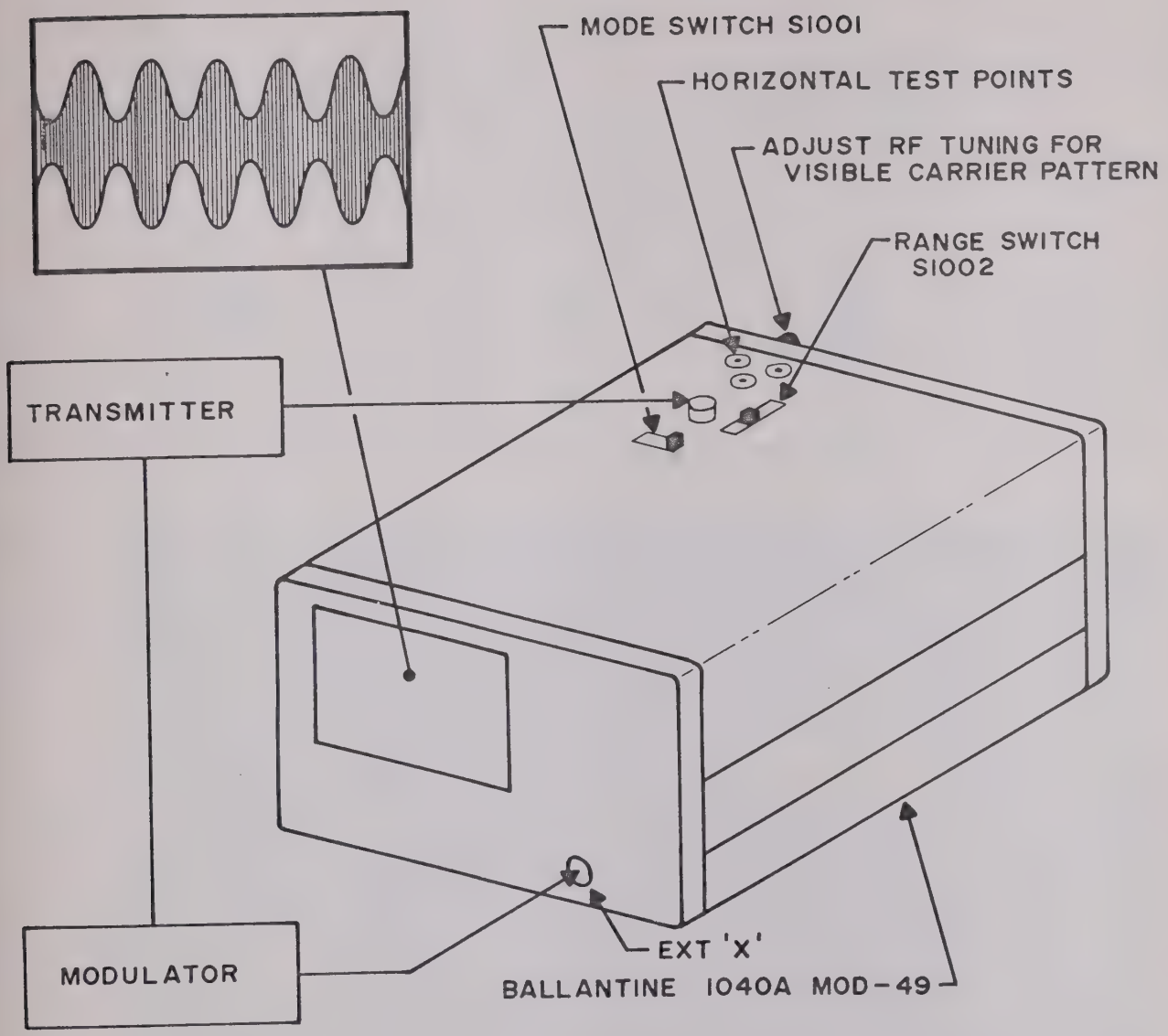


Figure A-1. Oscilloscope VHF Test Setup

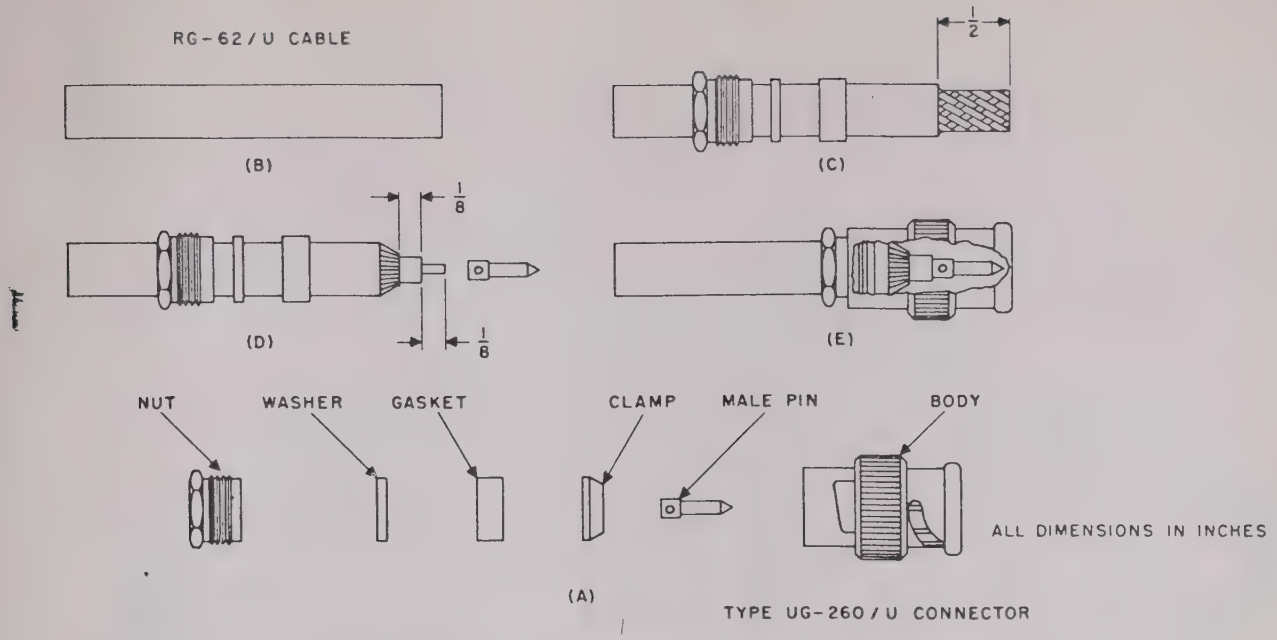
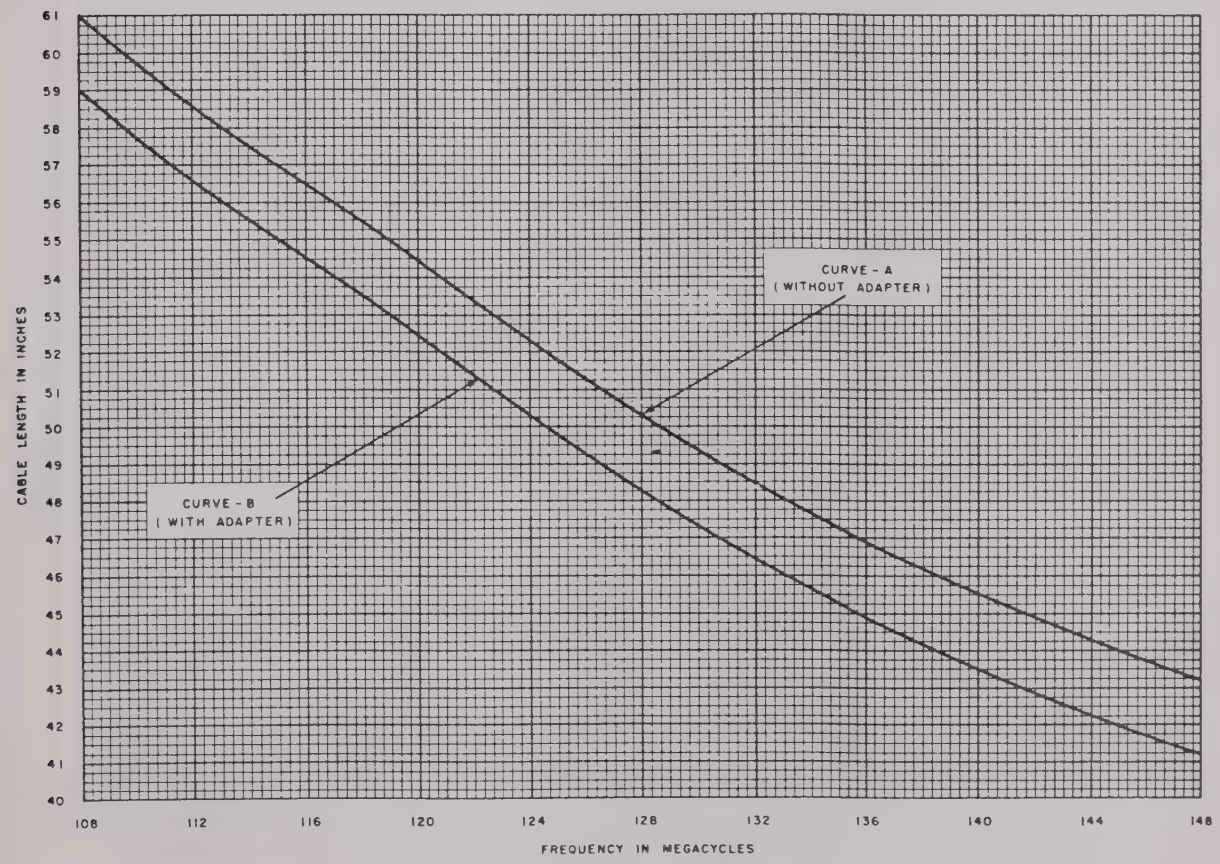


Figure A-2. Fabrication Diagram for RF Cables



NOTE: This chart is applicable to RG62/U 93Ω cable connected to the scope VHF input. The 1/4 wave length multiple will therefore not calculate based on cable length alone, but considers the cable matched to the VHF input impedance of the scope.

Figure A-3. Frequency Versus Length Chart, for RF Input Cables

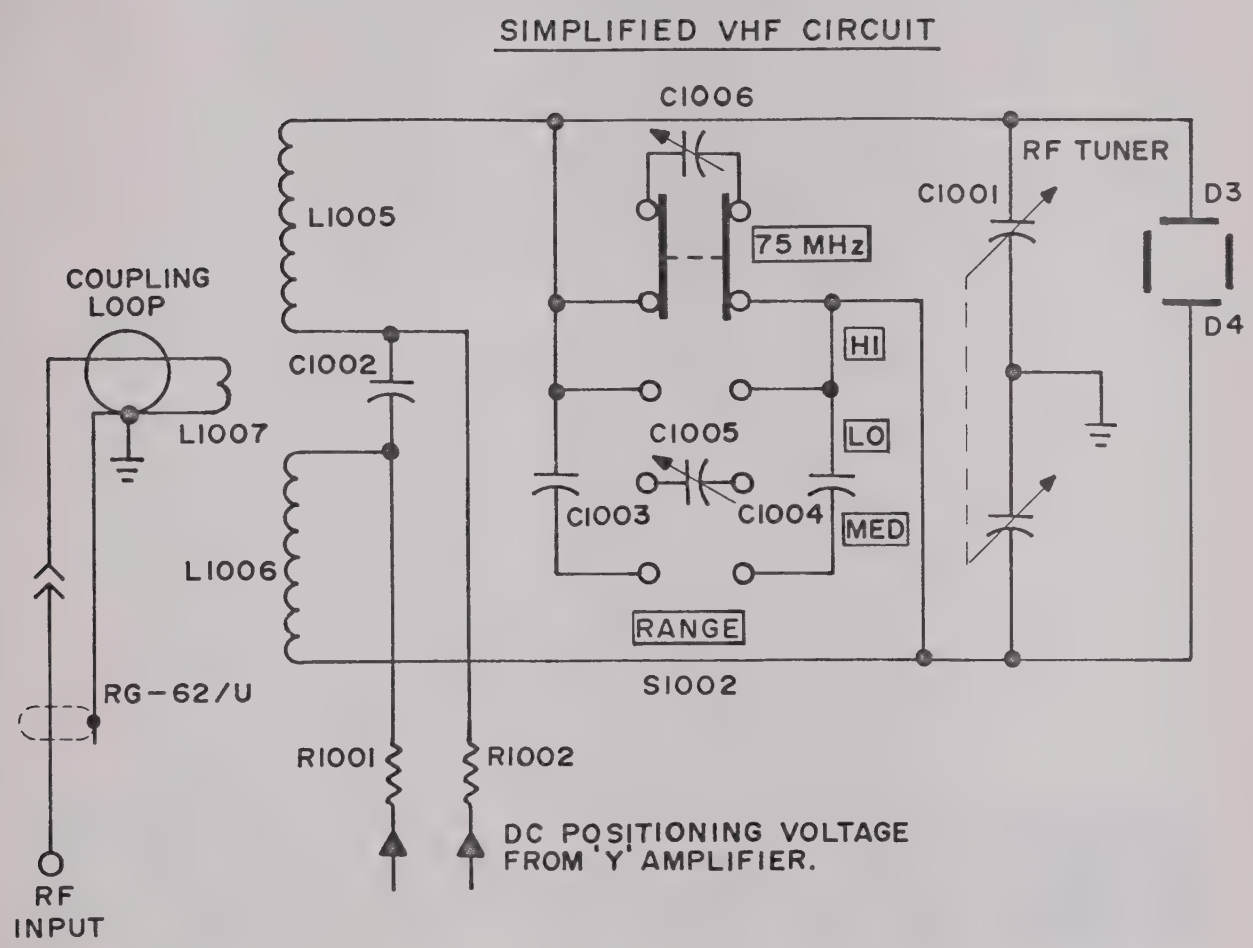


Figure A-4. Simplified VHF Circuit

CAUTION

The X test point tip jacks are dc coupled to the deflection plates. Their nominal common mode voltage to chassis ground is 50 to 75 Volts dc and their peak voltage may extend over the range of zero to 175 Volts above ground.

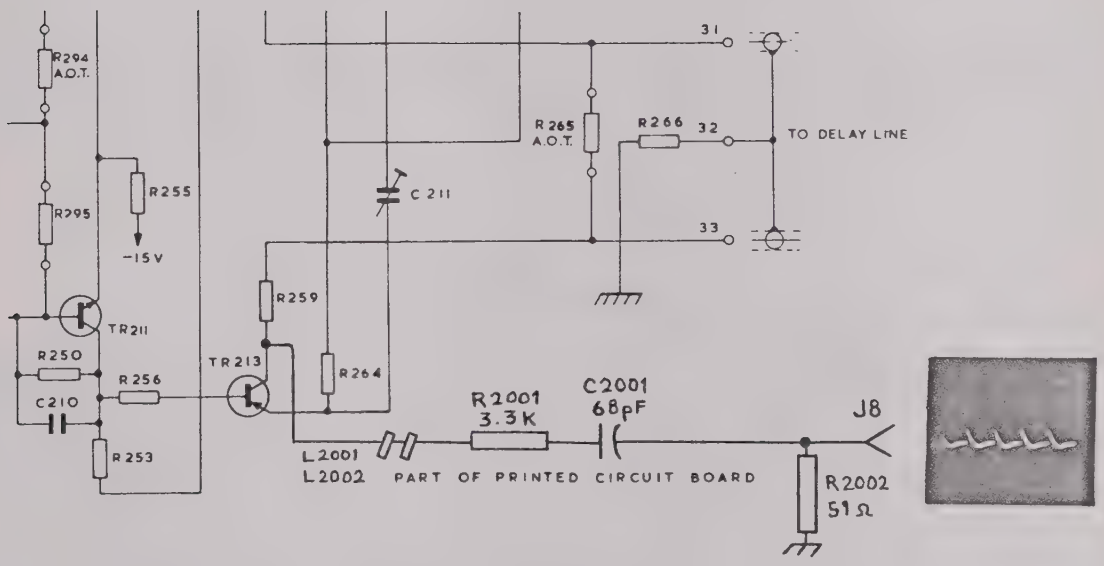
Use care to avoid personnel hazards associated with these voltages and avoid possible over-voltage damage to externally connected circuits.

2.5 VERTICAL MARKER CIRCUIT

2.5.1 The vertical marker circuit is a 50 ohm input which permits adding timing markers to the CRT display. The markers are ac coupled through a differentiating circuit which rejects low frequency components and are injected into the collector of TR213 which drives the vertical signal delay line. The schematic for the vertical marker circuit is shown in Figure A-5.

2.5.2

Delay Line Driver and Beam Switch



2.5.3 **CAUTION.** Do not apply large dc Voltages to Markers Input connector J8. DC Voltages over ±1 Volt will overload R2002, the 50 ohm terminating resistor. Always adjust the marker input amplitude to provide less than ±2.5 Volts (dc + peak ac).

2.5.4 The marker input is intended for narrow high frequency spikes less than 5μsec in width. Long pulses or low frequency sine waves (below 500 kHz) will be attenuated or rejected by series capacitor C2001 (60 pF).

SECTION 3
MAINTENANCE & CALIBRATION

3.1 GENERAL

The VHF circuit is designed and built so that comparatively little attention should be necessary, under normal conditions, to maintain the circuit in good working order. It must be recognized, however, that trouble could result some time during the life of the Ballantine Model 1040A MOD 49. What follows, therefore, should provide useful information for the location and correction of such trouble as may be encountered.

3.2 CORRECTIVE MAINTENANCE OF THE VHF BRACKET ASSEMBLY

The circuit components most likely to break down are those associated with coil assembly (L1005, L1006, C1002, R1001, and R1002). If one or more of these components prove defective, the entire assembly should be replaced as a unit. This procedure is suggested since the alignment of the balanced tank coil (L1005, L1006) with respect to the input link (L1007) located on the input connector bracket, is critical. However, individual circuit components may be replaced if extreme care is exercised during this replacement to maintain the turn spacing and distance between coils L1005 and L1006.

3.3 ACCESS TO THE VHF COMPONENTS

Remove the top cover. Remove vertical amplifier assembly and the tuning capacitor extension shaft before removing VHF bracket assembly. The retaining screws in the capacitor extension shaft are accessible through the hole in the VHF assembly bracket. Accessibility to the various components may then be readily obtained. The spacing of turns on the balanced tank coil (L1005 and L1006) as well as the distance between the two halves of the coil is critical. If the assembly is replaced as a unit, carefully note orientation of L1005 and L1006, and use special care to adhere to the original positioning of all components.

If C1002, R1001, or R1002 must be replaced, individually, special care must be exercised to see that the spacing of the balanced tank coil (L1005 and L1006) be maintained.

After replacement of the defective component(s), replace the VHF assembly taking care to avoid bending or misaligning the input link assembly. Replace the vertical output amplifier assembly and be sure to maintain low capacity lead dress. Use heat sink compound on the spacer mounting the output transistor bracket. After assembly, a check of the VHF circuit sensitivity should be made. Refer to the paragraphs entitled "Checking VHF Circuit Sensitivity" and VHF frequency range for proper procedure.

3.4 CALIBRATION PROCEDURE FOR 1040A MOD 49

The procedure will check the VHF circuit only. For other tests see the 1040A manual and/or calibration procedure. (See Schematic Fig. A-5).

3.5 TEST EQUIPMENT

TABLE I

TEST EQUIPMENT REQUIRED

DESCRIPTION	PURPOSE	RANGE OR CHARACTERISTICS
True RMS RF Voltmeter Ballantine Model 340 or Ballantine DMM Model 3028A with Model 10850B RF Detector Probe or Equivalent.	Measurement of R-F carrier Voltage.	Accurate beyond 150 MHz (±5%).
Unmodulated VHF Oscillator, GR 1215	To provide a source of R-F signals in the required frequency and amplitude range.	75 MHz and 108 MHz to 148 MHz
Frequency Counter Ballantine 5725B	Measure frequency.	10 Hz to 225 MHz.
Oscilloscope Calibrator Ballantine Model 6125B	Check rise time	<1 ns risetime into 50Ω
Signal Generator Tektronix 191	Check bandwidth	50 kHz to 100 MHz.
Digital Voltmeter Ballantine Model 3028A	Measure horizontal test point voltages.	1000 VDC Range

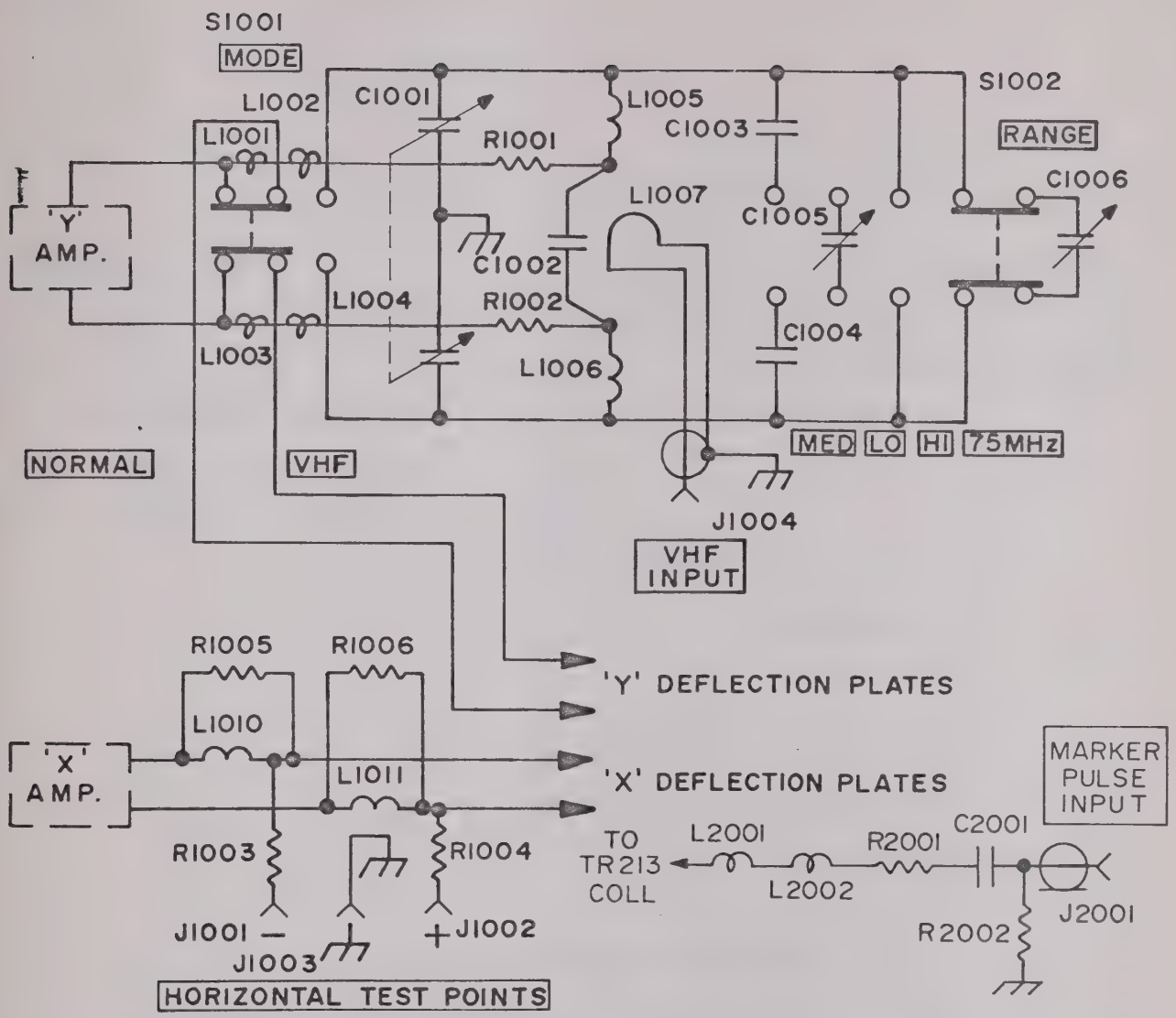


Figure A-5. VHF Schematic

3.6 VHF FREQUENCY RANGE

VHF frequency range should always be checked prior to making sensitivity adjustment. Use the test circuit of Figure A-6 for frequency range adjustments.

Remove vertical amplifier P.C. from frame and protect P.C. from accidental contact with frame. Add one short extension wire to CRT isolation shield pin.

Special care must be exercised in the handling and placement of vertical amplifier P.C. because of hazardous voltages present.

3.6.1 148 MHz ADJUSTMENT

Obtain a free running sweep at 1 mS/cm. Apply 6V rms at 148 MHz through a 3/4 wavelength cable to the VHF input. Rotate tuning capacitor C1001 and check that a deflection peak is obtained on the CRT with the capacitor plates virtually unmeshed. If necessary, check lead dress of components in the VHF enclosure to minimize stray capacity to ground. If necessary, carefully stretch the coils of L1005 and L1006 to raise frequency or squeeze coils to lower the tuning frequency. Be extremely careful not to damage the coils or alter the spacing around the coupling loop.

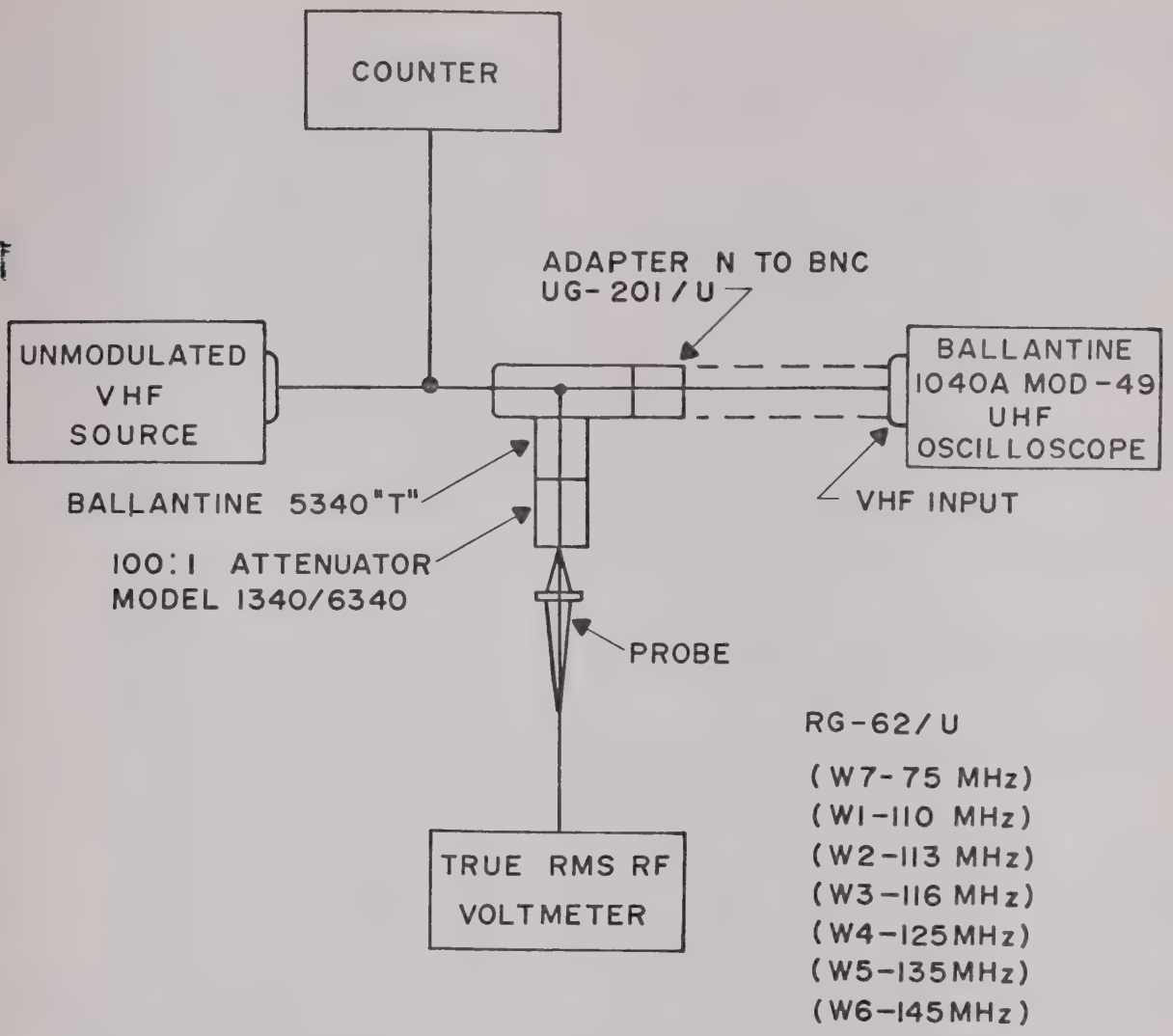


Figure A-6. Oscilloscope VHF Test Set Up

The 148 MHz tuning is accomplished when a peak in the CRT deflection is obtained just prior to minimum meshing of tuning capacitor C1001 plates.

3.6.2 75 MHz TEST

Apply 75 MHz to the VHF input. Set tuning capacitor C1001 until the plates are half meshed. Carefully adjust trip capacitor C1006 (located toward rear on S1002) with an insulated alignment tool until a peak is observed in the CRT display. The adjustment of C1006 must be made with care since its operation is very sensitive. Tuning capacitor C1001 should provide peaking at least over the narrow range of 74.7 MHz to 75.3 MHz.

3.6.3 LO RANGE ADJUSTMENT

Fully mesh C1001 plates and set C1005 for CRT peak display with 107.5 MHz input.

3.7 SENSITIVITY ADJUSTMENT

Figure A-6 shows the test setup for obtaining sensitivity measurements when a test oscillator is used as the unmodulated source which provides >5V rms output over the frequency range.

3.7.1 TEST PROCEDURE

Set the frequency of the unmodulated VHF source to the exact frequency for which the particular input cable is intended. (Check against the "Frequency Versus Length Chart" [Figure A-4] if necessary).

Apply 145 MHz and adjust the VHF input to the cable to within 2 to 10 Volts rms as measured by the R-F true rms voltmeter; noting the vertical beam deflection on the cathode-ray tube. The deflection should be 1.0 to 1.6 centimeters for each 2 Volts rms input. The VHF TUNING control must be adjusted for maximum deflection when making this check.

3.7.2
If the sensitivities obtained are not in agreement with Table 2, repositioning of the input coupling loop will be necessary, Carefully push the loop into axial adjustment with the two tank coils to increase sensitivity. Use great care and grasp the loop with long nose pliers without distorting the shape or damaging the enamel insulation on the wire. Pull the coupling loop out of axial alignment to decrease sensitivity. Move the coil perhaps 2 or 3 mm until the required vertical deflection is obtained. While making this adjustment, make certain that a constant VHF input voltage to the input cable is maintained.

When the input link has been adjusted for proper sensitivity, recheck the solder joints on the loop, the integrity of the enamel insulation, and that the loop does not touch the tank coils. Particular care should be exercised not to exceed the maximum deflection limit since to do so will result in lowering the input impedance to the cable.

NOTE The replacement of the cathode-ray tube necessitates a check on VHF sensitivity and possible readjustment of the input link as discussed above. It may also be necessary to slightly adjust coil spacing to compensate for CRT capacity change and obtain specified sensitivity at 145 MHz.

Components and lead dress are important to full range operation at highest sensitivity. Wider operation "off resonance" is normal. To obtain full range operation it may be necessary not only to dress leads and adjust coil spacing but C1003 and C1004 may also be reduced in capacity to raise the frequency in the MED range. These adjustments may be installed in some factory units and may be required in field maintenance.

3.8 FULL RANGE CHECK

Install vertical amplifier P.C. Assembly. Use care in arranging wires. Use heat sink grease on both sides of output transistor mounting spacer.

3.8.1 With C1001 plates still fully meshed for **maximum** capacity, check peaking frequency in LO, MED, and HI ranges.

LO_____MHz MED_____MHz HI _____MHz
(<108.0)

3.8.2 Fully unmesh C1001 plates for **minimum capacity** and check peaking frequency on LO, MED, and HI ranges.

LO_____MHz MED_____MHz HI _____MHz
(>148.0)

3.8.3 Check above readings to see that peaking can be produced with full overlap from 108 to 148 MHz, i.e., meshed MED range must be a lower frequency than the unmeshed LO range and the meshed HI must be lower than the unmeshed MED range.

3.9 RECALIBRATE THE VERTICAL AMPLIFIER RISE TIME AND RESPONSE.

Recheck that C358 is 33 pF.

3.9.1 RISE TIME: <9 ns _____nS

3.9.2 OVERSHOOT: <4% _____%

3.9.3 BANDWIDTH: 3 dB: >36 MHz _____MHz

Refer to 50 kHz at 6 cm. Measure frequency when amplitude decreases to 4.2 cm.

3.10 POLARITY CHECK OF VERTICAL AMPLIFIER, VHF, AND HORIZONTAL TEST POINTS.

3.10.1 With MODE switch in NORMAL position, see that CW rotation of vertical centering control will move trace up. Check vertical centering in same way except with MODE switch in VHF position.

3.10.2 Connect a Model 3028A DMM on 100VDC range between the two HORIZONTAL TEST POINTS. The positive Test Point is toward center of oscilloscope. Maximum CW rotation of the horizontal positioning control should produce reading of more than +80 VDC. Maximum CCW rotation, approximately –80 VDC. The MODE switch may be in either position for this test.

3.11 X-Y OPERATION.

3.11.1 The test jacks added to the horizontal deflection plates require the following change in the basic 1040A X bandwidth and X-Y phase response when testing according to the procedure of paragraph 5.5.18.6 on page 25.

TABLE 2
NORMAL VHF SENSITIVITY

RF INPUT VOLTAGE (RMS)	VERTICAL DEFLECTION (cm p-p)
5	2.5 min. to 3.3
10	5 min. to 6.6
Test at 145 MHz	

3.11.1.1 X Bandwidth dc to greater than 750 kHz at all settings of the Channel 2 Volts/cm switch from 5 mV/cm to 20 V/cm. Phase shift less than 3° at 100 kHz.

3.11.2 OPTIONAL X-Y PHASE SHIFT ZERO ADJUSTMENT.

3.11.2.1 C228 is selected to provide nominally zero (maximum 3 degrees) at 100 kHz. C228 is adjusted on test (a.o.t.) and falls in the value range of 8 pF to 47 pF. If desired C228b may be optionally installed in place of or in parallel with C228. C228b (P/N 07-10360-0A) is a 10-60 pF ceramic trimmer capacitor and is adjusted for zero phase shift at 100 kHz and may in most units be adjusted to provide less than 3 degrees phase shift to 250 kHz in the 1040A MOD49.

3.11.2.2 The X-Y phase shift is affected by the test points loading the X output amplifier. The X-Y phase shift is not factory controlled in the 1040A MOD49 series but may be adjusted as indicated above if desired during any routine recalibration. Wide bandwidth X-Y phase shift is not required for VOR certification.

SUPPLEMENTARY PARTS LIST

Schematic Symbol No.	Part Number	Parts Description
C1001	07-10240-0A	CVC, Dual 25 pF variable
C1002	07-09574-0A	CCD, 1.5 nF 1 kV disc
C1003	07-02286-0A	CCD, 39 pF 500V DM-15
C1004	07-02285-0A	CCD, 20 pF 500 V DM-15
C1005	07-02446-0A	CVC, 5.5-18 pF 350V variable
C1006	07-09151-0A	CVC, 8-50 pF 350V variable
J1001, J1002	31-10070-0A	Jack, Red tip
J1003	31-10071-0A	Jack, Black tip
J1004	31-03379-0A	Connector, UG-1094/U Panel Mounting BNC
C1953	07-02261-0A	Capacitor, CMD 620 pF 500 V (in parallel with C953)
L1001, L1002, L1003, L1004 L1005, L1006, L1007	46-10000-0A	Bead, Ferrite
L1010, L1011	03-10039-1A	Coil, RF Transformer
R1001, R1002	03-06285-0A	Coil, 200 μH
R1003, R1004	12-12568-0A	Resistor, 511K, 500 mW RN-60D
R1005, R1006	12-12759-0A	Resistor, 10.0K, 1.0W
R1983	12-12384-0A	Resistor, 7.5K 500 mW
	12-09839-0A	Resistor, 5.1Ω 1/4W RFC (in parallel with R983)

Parts list for oscilloscopes incorporating Marker Input:

R2001	12-01089-0A	3.3kΩ, 1/2W
R2002	12-12168-0A	51Ω, 1/2W
C2001	07-10029-0A	68 pF
L2001, L2002	46-10000-0A	Ferrite Beads
J8	31-03379-0A	Connector, UG-1094/U BNC

TEST PROCEDURE

for

VOR TEST GENERATOR

using

BALLANTINE 1040A-MOD 49A OSCILLOSCOPE

Ballantine Laboratories, Inc. P.O. Box 97 Boonton, New Jersey 07005 U.S.A.
Telephone: 201-335-0900 TWX: 710-987-8380

99-10031-5A

September 1975

1. PURPOSE.

1.1 It is the purpose of this test procedure to calibrate the VOR Test Generator using a Ballantine Model 1040A-MOD 49A Oscilloscope (see Figure 1). The VOR test generator, in conjunction with the VOR monitor, is used to determine the operational characteristics of the VOR facility. The accuracy of measurements is dependent upon the calibration of the test generator. An accurately calibrated test generator must be used for making a ground check of the facility. The following procedure shall be used in the calibration of the test generators.

2. REQUIRED TEST EQUIPMENT AND ACCESSORIES.

a) Oscilloscope: Ballantine Model 1040A-MOD 49A.

b) Interconnecting Cable (2 each): Phone plug to BNC (male) using 8 feet of RG-58C cable having a total cable capacity greater than 230 pF.*

c) Interconnecting Cable (1 each): Phone plug to tip plugs using 6 feet of RG-58C cable having a total cable capacity of approximately 190 pF.*

d) Interconnecting Cable (1 each): BNC male to BNC male. Use 4 feet of shielded cable such as RG-58C (Ballantine Model 12249D Cable Assembly).

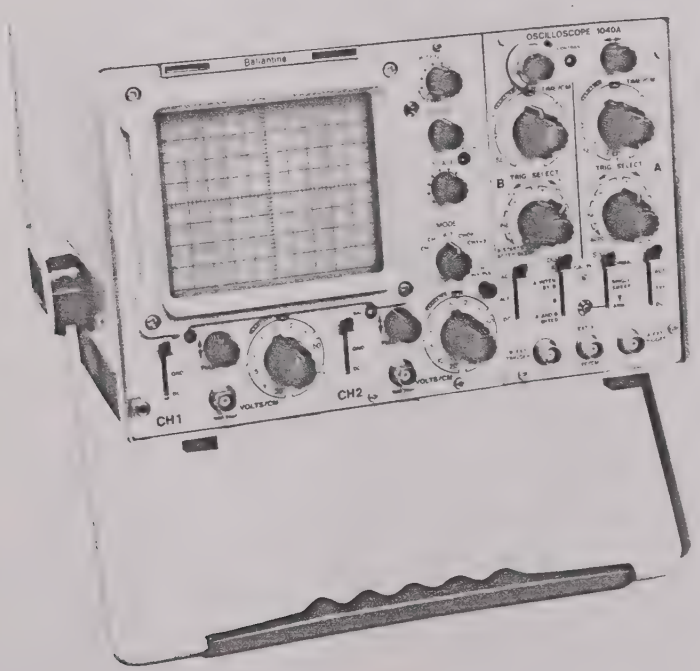


Figure 1. Ballantine Model 1040A-MOD 49A Oscilloscope

*Cable capacitances listed for reference only.

3. TEST PROCEDURE.

3.1 ZERO CALIBRATION. The term "zero calibration" refers to a fixed point calibration (90° in this case), as opposed to a check for accuracy throughout 360°. (The initial part of this procedure simply nulls out the phase shift in the related oscilloscope amplifiers.)

3.2 INTERCONNECTIONS. Connect the VOR Test Generator to the oscilloscope as shown in Figure 2.

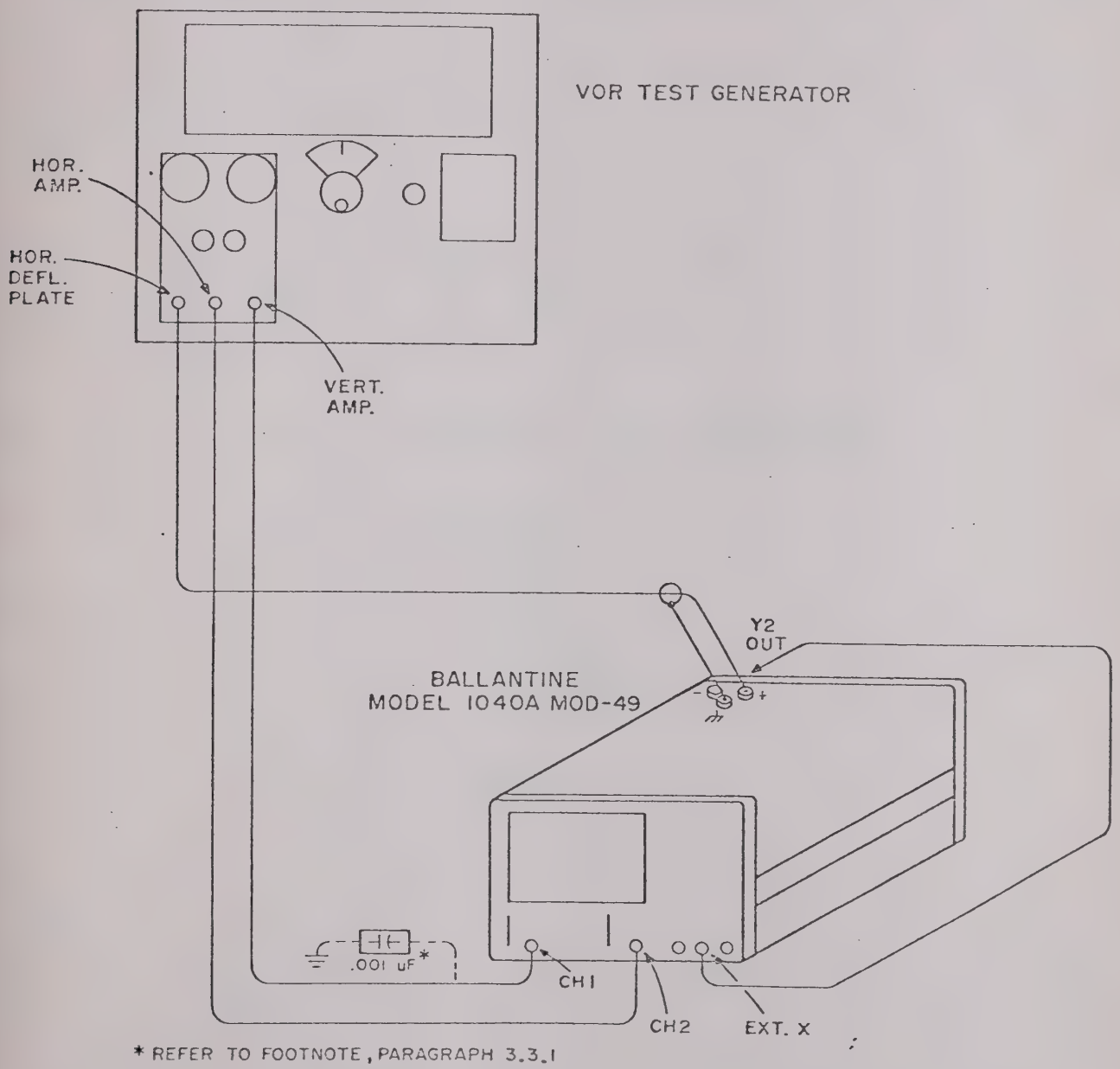


Figure 2. VOR Test Generator Test Set-Up

a) Connect the Y2 output BNC connector on the rear of the oscilloscope to the EXT X input BNC connector on the front panel. Use the shielded 4-foot cable terminated in BNC connectors.

b) Connect the HOR. AMP. output of the test generator to the CH2 input BNC of the oscilloscope. Use one of the two shielded 8-foot cables terminated in a phone plug and a BNC connector.

c) Connect the VERT AMP. output of the test generator to the CH1 input BNC of the oscilloscope. Use a shielded 8-foot cable terminated in a phone plug and a BNC connector.

d) Connect the HOR. DEFL. PLATE output of the test generator to the + (red) and case-ground (black) pin jacks of the HORIZONTAL TEST POINTS of the oscilloscope. (See Figure 3.)

WARNING

Always connect the phone plug end of the cable to the test generator BEFORE connecting the tip plugs to the oscilloscope HORIZONTAL (+) TEST POINTS pin jacks. The + HORIZONTAL TEST POINT is above case ground by an average of 80 volts dc. Failure to follow this connection sequence may cause shock and personal injury.

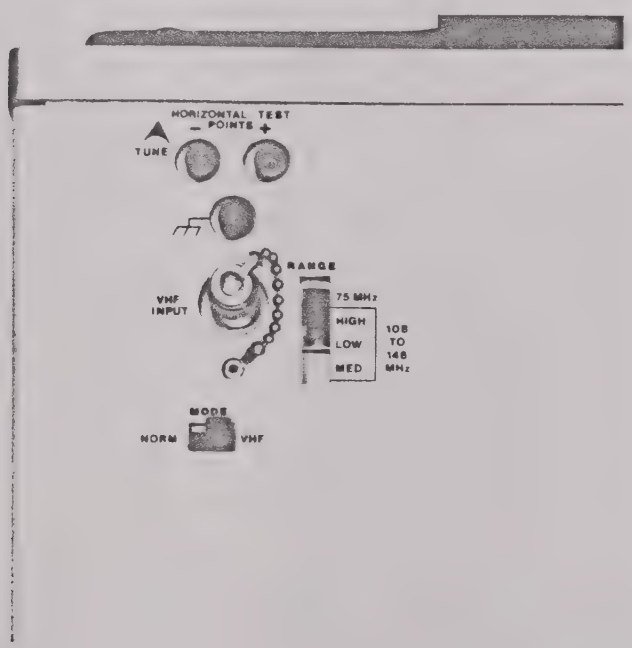


Figure 3. Oscilloscope Horizontal Test Points

3.3 CONTROL SET-UP.

3.3.1 OSCILLOSCOPE SETTINGS. Set the oscilloscope controls as follows (see Figure 4):

a) Vertical Controls

	CH1	CH2
CH1 and CH2 (coupling)	DC*	DC*
VOLTS/CM	10 mV	2 V
VOLTS/CM VARIABLE	CAL	CAL
PULL X5 MAG (position)	Centered/ Push In	Push In

b) MODE — CH1

c) DISPLAY — A

d) SWEEP — Normal

e) Time Base

	A	B
TIME/CM	EXT X	Not Used
PULL X10 MAG	PULL (out)	
TIME/CM VARIABLE	CAL	
AC-ACF-DC- (trigger coupling)	N/A	
TRIGGER SELECT	N/A	
LEVEL	N/A	
DELAY	N/A	

*DC input is preferred for phase shift conpensation, but AC coupling is permissible in either or both inputs if it provides better zeroing range for the VOR Test Generator Ph. Sh. NET controls. Should a phase zero not be obtainable for any combination of input coupling, then use DC coupling and insert a . 001 µF 400 volt capacitor in parallel with the CH1 input at the input BNC connector. Keep capacitor leads short and shield if necessary to avoid hum pickup. It is recommended that the capacitor be mounted in a shielded box such as the Pomona Electronics Model 3752 which also incorporates BNC connectors (see Figure 2).

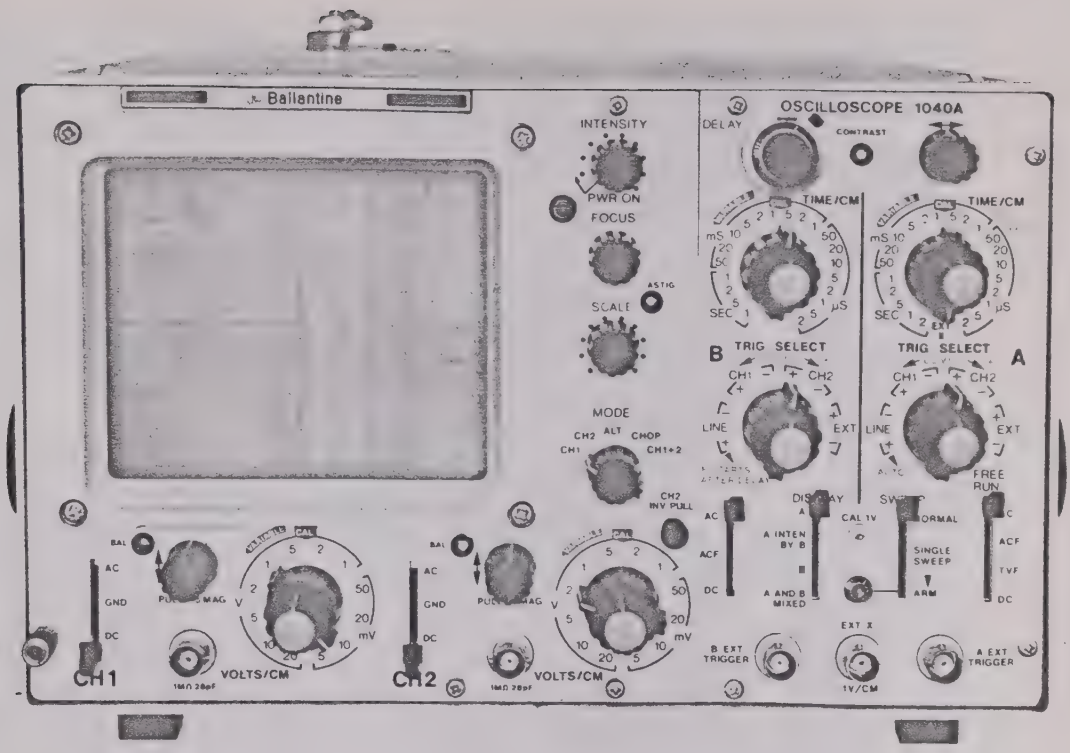


Figure 4. Oscilloscope Control Set-up

3.3.2 TEST GENERATOR SETTINGS. Set the VOR Test Generator controls as follows (see Figure 5):

a) CAL. GEN. -SCOPE PH COM. switch to CAL. GEN.

b) VARIABLE LEVEL control to 7.

c) CALIBRATE-OPERATE switch to CALIBRATE.

d) OUTPUT SELECTOR switch to No. 1 REF Ø, No. 2 VAR Ø

e) EXT-CAL SIGNAL LEVEL control to zero.

f) Adjust the REFERENCE LEVEL control for a 6 cm wide horizontal deflection on the oscilloscope.

g) Now place CAL GEN-SCOPE PH COM switch to SCOPE PH COM positi

NOTE

Figure 5 is a photograph of the VOR Test Generator front panel. The settings of the controls shown are typical and do not necessarily agree with the settings called out in paragraph 3.3.2.

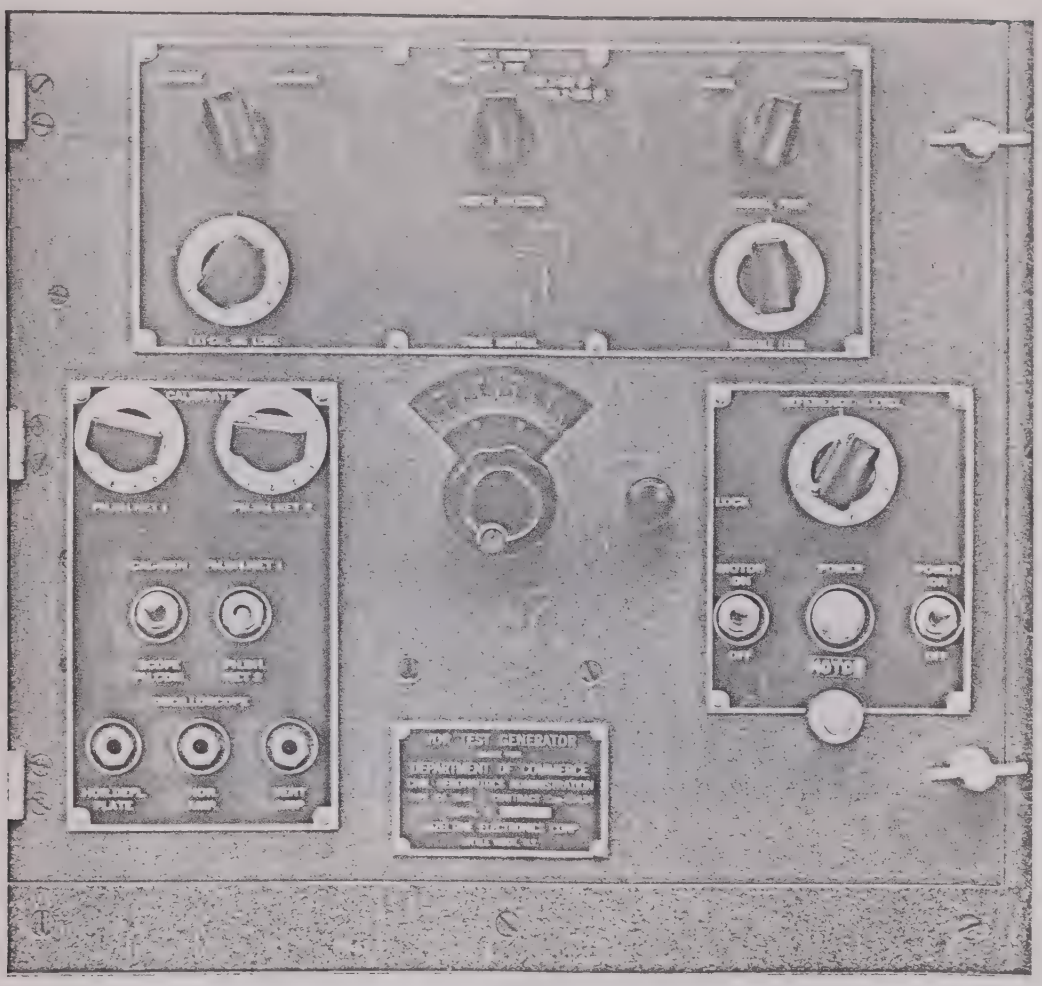


Figure 5. VOR Test Generator Control Set-up

3.3.3 CONTROL ADJUSTMENT FOR PROPER DISPLAY.

a) Adjust the oscilloscope intensity and focus controls for a fine discernible trace.

b) Temporarily remove the vertical deflection (CH1) on the oscilloscope by setting the CH1 input coupling switch to GND.

Observe a horizontal trace. Position it so it is centered on screen and adjust the CH2 VOLTS/CM and VARIABLE controls for a 6 cm trace length.

Return the CH1 input coupling switch to DC.

c) Adjust the PH. SH. NET 1 or PH. SH. NET 2 control (whichever permits phase coincidence to be obtained) for two superimposed slant lines. See Figures 6 (out of phase) and 7 (in phase).

NOTE

Although the 1040A-MOD 49A oscilloscope generally does not exhibit on-screen overload phase distortion, it is desirable to check for best maximum signal level without distortion.

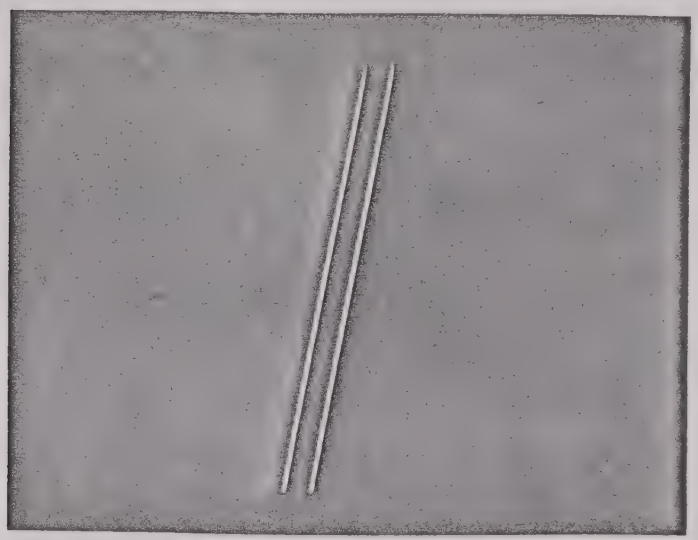


Figure 6. 30-Hz Out-of-Phase Display

Figure 7. Proper 30-Hz Phase Coincidence

d) Overload Distortion Check. In compensating for the phase shift in the oscilloscope, the best resolution will be obtained when the amplitude of the variable (30 Hz) test signal is large: however, if this level is too high, the oscilloscope amplifiers become overdriven, resulting in distortion and erroneous phase indication. To determine the maximum setting of the variable level control for the best resolution without distortion, the following procedure should be used:

Adjust the VARIABLE LEVEL control for good resolution, and the applicable PH. SH. NET control for two superimposed slant lines. Decrease the variable signal output from the test generator. If the phase coincidence, as noted on the oscilloscope changes, the signal level is too high. It will be found that, once the level control has been set at the maximum allowable level, a decrease in level will not cause a change in the "in-phase" indication. (i.e. lines did not move apart.)

e) Remove the tip jack on the connecting cable from the oscilloscope + HORIZONTAL TEST POINT and reconnect it to the - HORIZONTAL TEST POINT tip jack. If the slant lines separate to indicate a phase shift, the oscilloscope is not properly balanced or is malfunctioning and corrective action should be taken on the oscilloscope.

f) This calibrates the oscilloscope for 30 Hz phase shift coincidence.

3.4 TEST GENERATOR CALIBRATION.

3.4.1 PROCEDURE. After calibrating the oscilloscope for 30 Hz phase shift proceed as follows:

a) Set the CAL GEN-SCOPE PH COM switch of the VOR Test Generator in the CAL GEN position.

b) Remove the connecting cable from the HORIZONTAL TEST POINT tip jacks on the oscilloscope and also remove the phone jack connector end of the cable from the HOR. DEFL. PLATE output of the test generator.

NOTE

Removal of the connecting cable will eliminate possible distortion in the ongoing calibration procedure.

c) IMPORTANT! Remove the cable from OUTPUT NO. 1 at the rear of the VOR Test Generator and connect it to OUTPUT NO. 2 (see Figure 8). This step permits presenting the same load to the 30 Hz output of the VOR Test Generator for calibration purposes as that which is connected during normal operation.

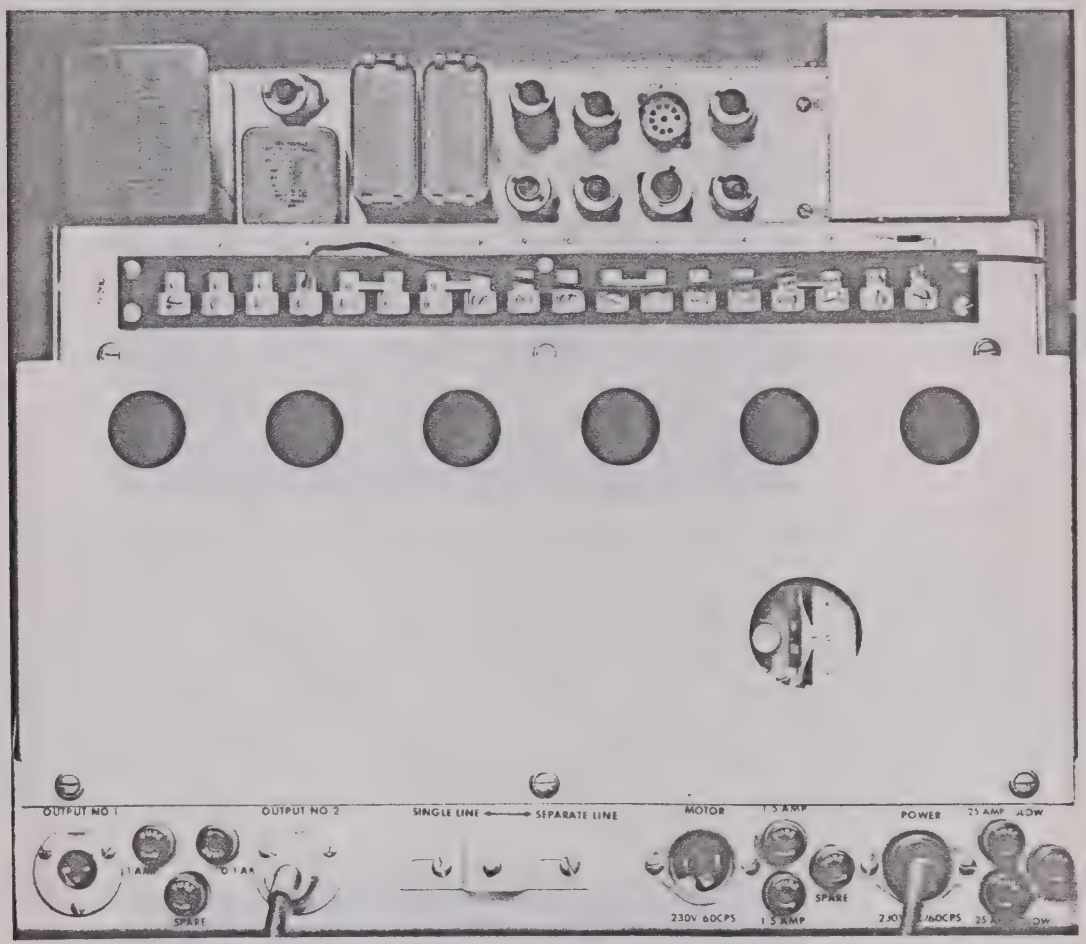


Figure 8. VOR Test Generator, Rear View

d) Set the REFERENCE LEVEL control for a 5 cm p-p horizontal deflection on the oscilloscope.

The test generator VARIABLE LEVEL control must remain as previously adjusted. Any readjustment of this control requires re-checking of the oscilloscope 30 Hz phase shift compensation performed previously.

e) To avoid overdriving the oscilloscope vertical amplifiers set the CH1 VOLTS/CM and VARIABLE controls to obtain an 8 cm vertical display. Then increase the CH1 VOLTS/CM switch sensitivity (turn clockwise) by two (2) steps and pull (out) the CH1 PULL X5 MAG control. Observe a pattern similar to Figure 9 on screen.

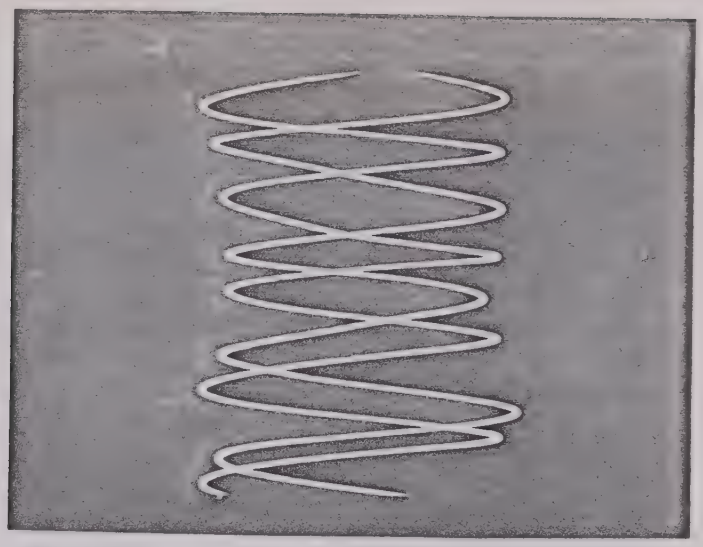


Figure 9. Tone Wheel Pattern Display With Limiting

f) Rotate the phase control dial on the VOR Test Generator to exactly 90 degrees. Set the test generator limiting control (screwdriver access within generator) to remove amplitude limiting so that the two short waveforms appear. See Figure 10. Adjust the CH1 Position control on the oscilloscope until the two short waveforms produced by the filed teeth on the tone wheel appear in the center of the oscilloscope screen.

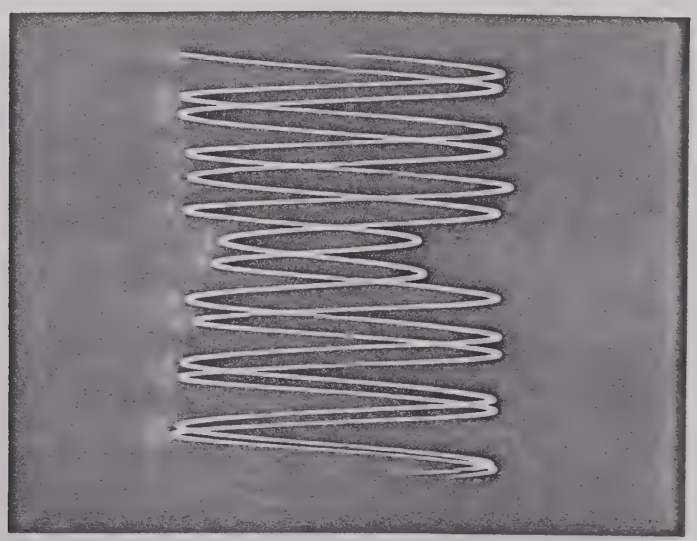


Figure 10. Tone Wheel Pattern Display Without Limiting

g) Rotate the generator phase control dial until the two short waveforms coincide and appear on the right side of the oscilloscope pattern, Figure 11. Note the phase control dial setting.

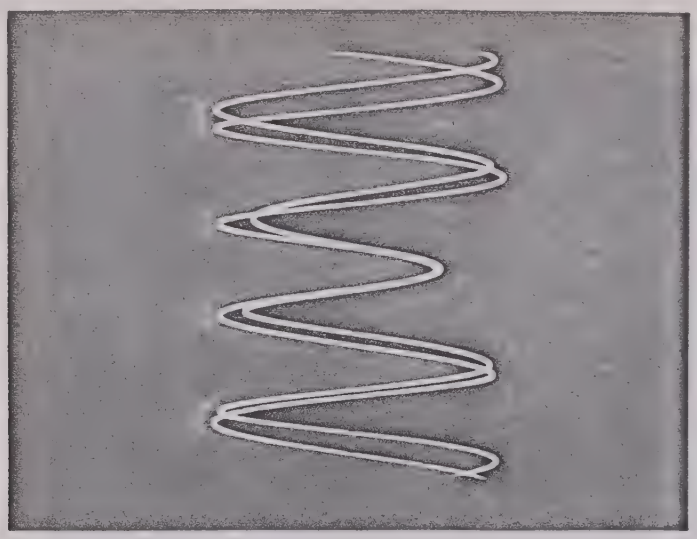


Figure 11. Right Hand Coincidence

h) Rotate the VOR Test Generator PHASE CONTROL dial through the 90-degree position, and adjust until the two short waveforms coincide on the left side of the oscilloscope pattern, Figure 12. Note the PHASE CONTROL dial setting.

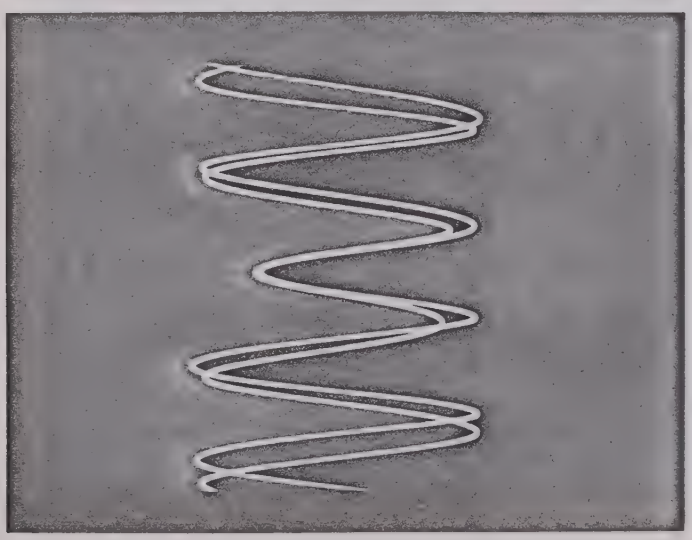


Figure 12. Left Hand Coincidence

i) Rotate the VOR Test Generator PHASE CONTROL dial to a position half-way between the two dial settings noted above. The waveform will now appear as shown in Figure 13 or Figure 14. The two short waveforms should cross as shown in Figure 14 with the PHASE CONTROL dial set at exactly 90 degrees.

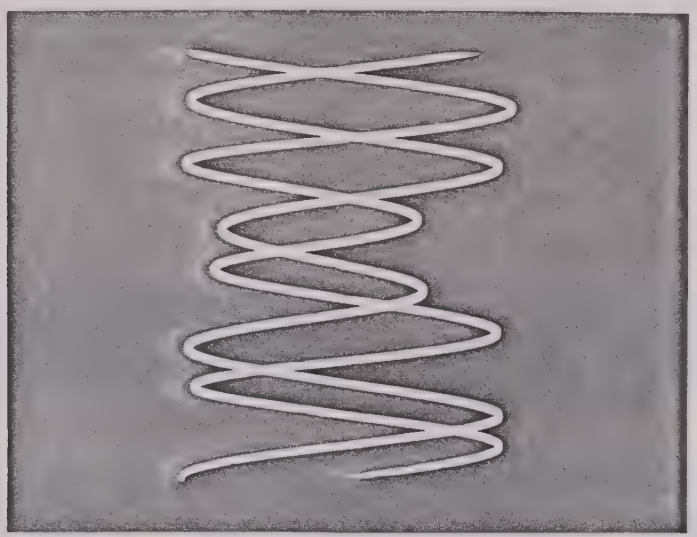


Figure 13. Incorrect Tonewheel Pattern Display At 90°

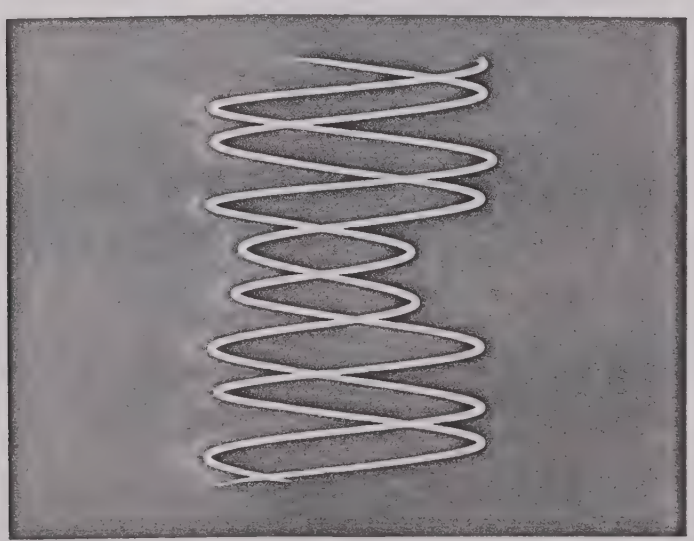


Figure 14. Proper Tonewheel Pattern Display At 90° After Tonewheel Pick-up Adjustment

j) If the two short waveforms do not cross with the PHASE CONTROL dial setting at exactly 90 degrees it will be necessary to re-adjust the position of the tonewheel pick-up with respect to the periphery of the tonewheel until the two short waveforms do cross as in Figure 14 with the PHASE CONTROL set at 90 degrees.

CAUTION

The tonewheel is motor-driven and care must be used when making the pick-up adjustment to avoid personnel hazard due to rotating equipment.

Lock the tonewheel pick-up locking screw (see Figure 15) after adjustment and check that the two waveforms continue to cross exactly as indicated on Figure 14.

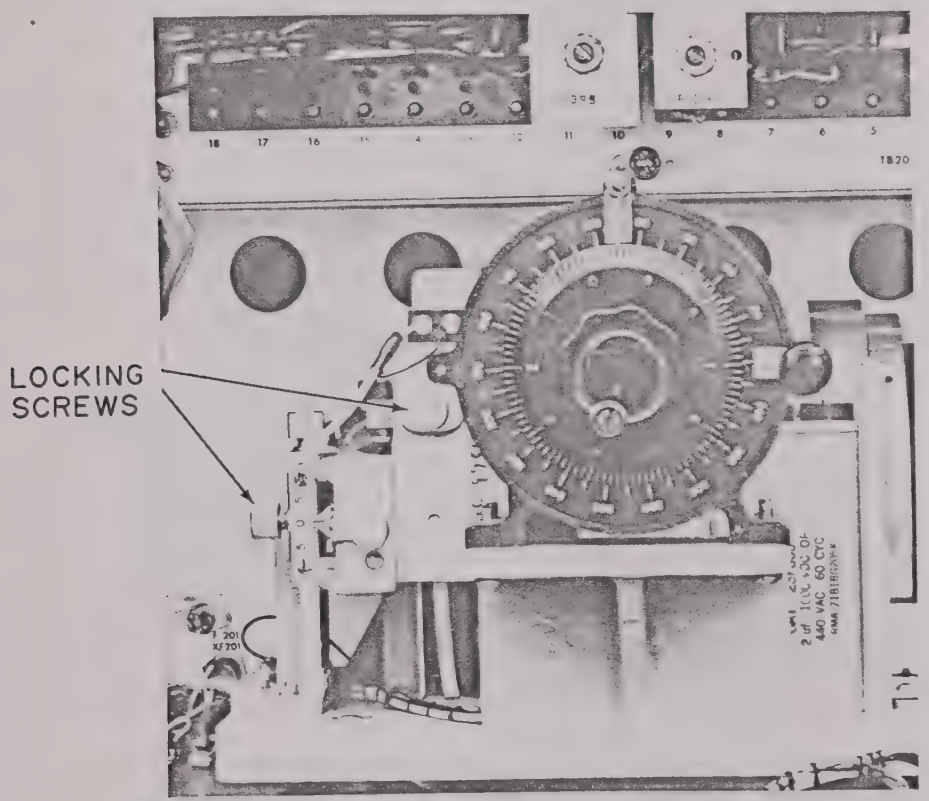


Figure 15. Tonewheel Pick-up Locking Screws

3.4.2 Check for Accuracy of Generator Throughout 360°. This procedure involves a consideration of the tonewheel teeth spacing and offers a method of checking the accuracy of the PHASE CONTROL dial reading throughout its range of 360°.

a) Connect the oscilloscope as for test generator calibration. The PHASE CONTROL dial should read 90° when the proper crossover point is indicated (see Figure 14) in accordance with the previous superposition calibration procedure.

b) Adjust the oscilloscope vertical gain so that approximately 10 complete waveforms appear on the face of the oscilloscope. The oscilloscope pattern will be similar to Figure 14 except that more cycles appear on screen. This display is set-up by decreasing CH1 VOLTS/CM control by one step (turn counterclockwise).

c) Starting for 90°, rotate the PHASE CONTROL dial in a clockwise direction until two of the shortened waveforms become coincident on either the right or left side of the oscilloscope face. The presentation will appear as in Figure 11 or 12. The PHASE CONTROL dial will now read about 90.25°. This is the starting point. Position this coincidence point to the center graticule line on the CRT screen using the CH1 position control.

d) Rotate the PHASE CONTROL dial in a clockwise direction until two more waveforms become coincident near the center graticule line at the same place on the oscilloscope face at which coincidence of the previous waveforms occurred. (In rotating the dial for waveform coincidence, the waveforms will become coincident once in between the desired coincident points; however, the correct coincident point is the one which occurs at approximately the same position on the oscilloscope face as did the preceding correct coincident point. No difficulty will be experienced in determining which coincidence is the correct one.)

e) Continue to rotate the dial in a clockwise direction until 10 correct coincident points have been counted. Record the phase dial reading obtained at the 10th coincident point. As shown in Table 1, the reading should be 101.12 degrees. Any departure from this is the error of the generator at this setting. (In observing coincident points, it will be noticed that there is a slight change in the correct position for each succeeding correct coincident point. This is normal and is not an indication of inaccuracies. However, it will help avoid confusion if the CH1 Position control of the oscilloscope is adjusted to reposition the last correct coincident point to the center reference line on the graticlue after each 10 coincident points have been counted.)

f) Continue to rotate the PHASE CONTROL dial in a clockwise direction, recording the phase dial reading for every tenth correct coincident point. The reading which should be obtained for every tenth coincident point is shown in Table 1. The final reading, of course, is only two coincident points from the 33rd reading since there are a total of 332 teeth.

NOTE

A possible source of error in this method is hum in the oscilloscope display. The degree in error from this source can be determined by the following method:

(1) Adjust the oscilloscope as in Step (a) above.

(2) Turn the phase-lock-in control (motor stator) through as near 360° as possible. If the phase relationship between any two waveforms on the oscilloscope screen changes more than 0.1 degree (plus or minus 0.5 degree) the hum is considered excessive. If the hum exists in the oscilloscope display, the phase relationship between the waveforms nearest the edge of the screen will change more than that between those in the center of the oscilloscope screen when the phase-lock-in control is turned.

TABLE 1. CHECK FOR ACCURACY OF VOR TEST GENERATOR THROUGHOUT 360° AMBIT OF PHASE DIAL

Coincident Points	Test Generator Reading
Start	90.25°
10	101.12
20	111.98
30	122.84
40	133.69
50	144.53
60	155.36
70	166.18
80	177.00
90	187.82
100	198.64
110	209.47
120	220.30
130	231.15
140	242.00
150	252.86
160	263.73
170	274.60
180	285.46
190	296.33
200	307.18
210	318.02
220	328.86
230	339.69
240	350.51
250	1.33
260	12.15
270	22.97
280	33.80
290	44.64
300	55.48
310	66.34
320	77.20
330	88.07
332	90.25

3.5 RESETTING VOR TEST GENERATOR.

a) Reset VOR Test Generator limiting control for proper limiting action. (All 10 kHz cycles of equal p-p amplitude and the two short cycles disappear.) See Figure 16.

b) Reconnect the cable of the rear of the VOR Test Generator from "OUTPUT No. 2" back to "OUTPUT No. 1" for normal operation. See Figure 8.

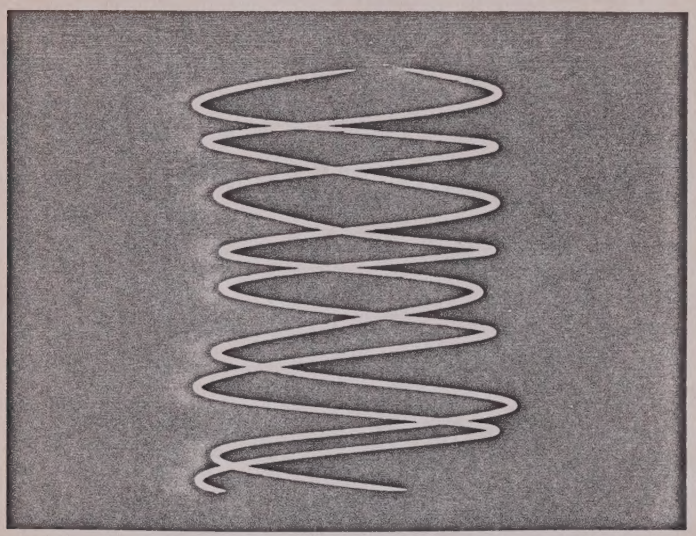


Figure 16. Tone Wheel Pattern Display With Limiting

MP MASTER
MA31962